



**Implementing Early Detection in  
Hawai'i, Year One**

**Hawaii  
Biological  
Survey**

**Final Report**

**December 2007**

**Implementing Early Detection in Hawai'i, Year One**

**Final Report prepared for:**

**Hawaii Invasive Species Council  
Research and Technology Program  
Department of Land and Natural Resources,  
Division of Forestry and Wildlife**

**Prepared by:**

**Clyde T. Imada, Danielle Frohlich, Alex Lau, and Ryan Smith**

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EXECUTIVE SUMMARY

HISC contract #54712, "Implementing Early Detection in Hawai'i," is a positive vigilant step toward ensuring that O'ahu avoids future blindsidings by incipient invasive plant species. Partners Bishop Museum (BISH) and the O'ahu Invasive Species Committee (OISC) hired two research and field staffers, coined the O'ahu Early Detection (OED) team, who were trained by BISH staff in plant identification skills and use of herbarium resources, and provided technical and field assistance by OISC staff. OED staff initially conducted a baseline inventory of cultivated plants grown on O'ahu, covering a variety of importation sources such as botanical gardens, nurseries, community gardens, and agricultural research centers. The preventative protocol they followed is designed to spotlight any species fitting a particular profile (as suggested by Weed Risk Assessment, behavior elsewhere in the world, life history strategies of confamilial species, etc.) and mark them as high-risk species meriting preventative control efforts. As of mid-June 2007, OED had embarked on the roadside survey phase of their program, already surveying 212 miles of road in 14 neighborhoods. They also surveyed about 30 plant establishments, including over 15 commercial and retail nurseries and 4 botanical gardens. Highlights of their surveys include a target list of 153 high-risk species, and 12 new naturalized weed records for the state and 13 others for O'ahu. About 300 plants have been identified for U.S. Army Natural Resources, OISC, Maui Land & Pine, and U.S. Geological Survey. New findings were published in Bishop Museum's Records of the Hawaii Biological Survey in October 2007.

## **I. INTRODUCTION**

Hawai‘i’s unique isolation makes it particularly susceptible to biological invasions, and it has been abundantly demonstrated that many aggressive plant and animal species not yet established in Hawai‘i can, if introduced, permanently alter our unique landscape, leading to species extinction, environmental degradation, and enormous economic strain. It has been said that an estimated 20–50 new species become established in Hawai‘i every year, so an effective system of prevention and early detection is imperative for safeguarding Hawai‘i. The island-based Invasive Species Committees (ISCs) have proven to be an effective mechanism for rapid response to, and control of, incipient pest species, but they have lacked a comprehensive early detection program for ensuring the greatest probability of detecting new invasive species.

While there have been several successful early detection efforts in Hawai‘i, they stand as isolated island-specific projects. Bishop Museum (BISH) and the O‘ahu Invasive Species Committee (OISC) have joined forces in a long-term partnership to procure stable funding for the early detection of, and rapid response to, invasive species in Hawai‘i. Hawaii Invasive Species Council contract #54712, “Implementing Early Detection in Hawai‘i,” provided funding for the first year of a three-year project to develop and implement a statewide program of comprehensive early detection, and for its initial implementation on O‘ahu. This funding allowed for the hiring of two biologists (Danielle Frohlich, Alex Lau) trained in invasive species management, who received additional training in herbarium management and plant identification methods, and were primary participants in all phases of the project. This duo was coined the O‘ahu Early Detection (OED) team.

This project had three main thrusts, which are dealt with in detail in the sections to follow.

- **Detection Plan Model:** Using past research and experience, a draft model was created to establish protocols that will help all ISCs pinpoint new invasive species before they can become established beyond hope of eradication. This model incorporates the need to systematically re-evaluate detection strategies and resurvey identified pathways and high-risk sites to achieve continual comprehensive early detection of our islands, and can be tailored to suit the needs of individual islands. Biologists Forest and Kim Starr lent their detection expertise in developing the plan.
- **Rapid Identification Program:** Training OED staff in plant identification skills was integral to fulfilling this phase of the project, which provides for quicker turnaround of plant IDs for potentially invasive plant material brought to BISH by resource management staff of various agencies on O‘ahu (e.g., OISC, U.S. Army Environmental, State Department of Agriculture). Rapid identification allows for more informed and timely decision-making by resource management staff on the threats posed by a particular weed, and appropriate management actions. OED is projected to be a stable, centrally located resource that can assist weed management staff with IDs statewide and also perform early detection surveys.
- **O‘ahu Early Detection Program:** The draft Detection Plan Model has been successfully tailored for use on O‘ahu, where OED implemented the first year of a 3-year, on-the-ground detection program. Data from the first year is being used to further refine the model.

### **Project Timeline**

December 2005: Tentative notice of approval for HISC funding via Mark Defley, pending DLNR Board approval

February 2006: Drafted position descriptions for two detection positions (Bishop Museum, OISC)

March 2006: Advertised for two detection positions (Bishop Museum, OISC)

May 2006: Principal Investigators Ryan Smith (OISC) and Clyde Imada (BISH) visit Forest & Kim Starr on Maui to review their weed detection survey protocols

April–June 2006: Interviewed job applicants (Bishop Museum, OISC)

July 2006: Hires Danielle Frohlich and Alex Lau start work; coined Oahu Early Detection (OED) team.

August 2006: Official start date of project; fully executed signed contract received from HISC. Forest & Kim Starr train OED on weed detection survey protocols.

September 2006: Project progress report sent to HISC

September 2006: “Hot spot” surveys begin



December 2006: Phase 1 of “hot spot” surveys complete  
March 2007: Initial roadside surveys begin  
August 2007: Finalized roadside target list  
September 2007: Phase 2 of roadside surveys begins  
November 2007: Final project report sent to HISC.

### **Project Personnel and Partners**

The success of this project hinged largely on hiring capable, motivated individuals to make it work. We feel we hired two such individuals. *Danielle Frohlich*, finishing up an M.S. degree in Botany at the University of Hawai'i at Manoa, was hired as a Research Specialist to lead the project. She came in with a strong background in invasion biology and plant taxonomy, and had already demonstrated her botanical skills and motivation while doing volunteer work in Herbarium Pacificum at Bishop Museum. *Alex Lau* (B.A./B.S. in Biology and Ecology, The Evergreen State College) arrived straight from a stint with the O'ahu Invasive Species Committee (OISC) field crew. He was hired as a Collections Technician to assist Danielle in laboratory and field work, but the intimate knowledge of alien species gained while working for OISC made him an invaluable addition that complemented Danielle's skills. They are stationed at Bishop Museum's Department of Natural Sciences/Botany. *Clyde Imada*, Research Specialist, served as the principal investigator for the project and co-managed it with Ryan Smith of OISC. *Napua Harbottle*, Collections Manager of Botany, assisted with the interview process and oversaw training of Danielle and Alex in the workings of an herbarium; Collection Technician *Barb Kennedy* also assisted. Drs. *George Staples* and *Derral Herbst* provided over 100 hours of their time in expounding on the fine art of plant identification and taxonomy. *Pau McDonald* provided volunteer plant mounting assistance.

*Ryan Smith*, coordinator of the O'ahu Invasive Species Committee (OISC), co-managed the project with Imada. He played an integral role in selecting OED staff and in coordinating and overseeing the development of all the protocols and plans for this proposal, and was responsible for coordinating with the various partners and resources to ensure project success. OISC staff coordinated with OED to provide many services. *Rachel Neville*, in her public relations role with OISC, helped to publicize OED's efforts by arranging for television media coverage and for invitations of OED to explain their project at various plant-related venues. *Jean Fujikawa*, OISC GIS specialist, spent many hours helping OED with ARCVIEW maps for the project. OISC field staff was involved in control/eradication and monitoring of incipient target species discovered by OED staff. *Lara Reynolds* of the OISC field crew assisted OED with creation of species profiles, in exchange for occasional OED participation in OISC field surveys.

*Forest and Kim Starr*, biological consultants based on Maui, were contracted to assist in the development of all the project's protocols and action plans. They have much experience conducting early detection roadside surveys on Maui and Moloka'i, and have performed botanical and detection surveys throughout the state. They also provided in-kind services to teach OED their survey and detection methodology, and to provide field and species identification assistance.

*Pacific Basin Information Node*. The U.S. Geological Survey—Biological Resources Division (USGS—BRD) Pacific Basin Information Node (PBIN) is working to build the technical infrastructure to support statewide early detection efforts. PBIN will play a vital role in ensuring that the databases and data collection and reporting methodologies meet statewide standards and facilitate the integration of early detection data into one statewide system. PBIN provided in-kind-services as a data consultant for this project.

*Hawai'i Detection Community*. This represents a diverse collaboration of resource managers and scientists who have historically been involved in early detection strategies and field programs in Hawai'i. This community will provide integral counsel and input to the development of the Detection Plan Model and the O'ahu Early Detection Program. Individuals and organizations include *Anne Marie LaRosa* (U.S. Fish and Wildlife Service), *Lloyd Loope* and *Kealii Bio* (USGS—BRD), *Teya Penniman* (Maui Invasive Species Committee), *Keren Gunderson* (Kaua'i Invasive Species Committee), *Julie Leialoha* (Big Island Invasive Species Committee), *Lori Buchanan* (Moloka'i Invasive Species Committee), *Julie Denslow* (Institute of Pacific Islands Forestry), *Carter Smith* (Coordinating Group on Alien Pest Species), *Kapua Kawelo* (U.S. Army Natural Resources), *Guy Ragosta* and *Micah Ryder* (Ko'olau Mountains Watershed Partnership

[KMWP]) *Joel Lau* (Hawai‘i Biodiversity & Mapping Program), *Curt Daehler* and *Richard Criley* (University of Hawai‘i at Manoa), *George Staples* and *Derral Herbst* (Bishop Museum [BISH]), *Betsy Gagné* (Natural Area Reserves Commission), *Hank Oppenheimer* (Maui Land & Pine), *Dave Lorence* and *Tim Flynn* (National Tropical Botanical Garden), *Chris Dacus* (Hawai‘i Department of Transportation [HDOT]), *Neil Reimer* (Hawai‘i Department of Agriculture [HDOA]), *Philip Thomas* (Hawaiian Ecosystems At Risk [HEAR}), *Ray Baker* and *Shahin Ansari* (Lyon Arboretum), *David Orr* (Waimea Audubon Center), and staff of U.S. Department of Agriculture (USDA) Animal & Plant Health Inspection Service.

## **II. DETECTION PLAN MODEL**

The first component of this project builds on previous detection efforts in Hawai‘i and elsewhere. How can the ISCs make early detection of new invasive species comprehensive and systematic? When does a species merit control? How do we achieve comprehensive detection on O‘ahu? It establishes a model that all ISCs statewide can follow outlining the steps that should be taken for developing the capacity to rapidly respond to new introductions before they become established beyond hope of eradication, but tailored for local implementation on each island. This work entails collaboration with researchers and managers across the state.

Four component documents are included. **Ia. Building a Target Species List** (page 1) addresses methodologies for arriving at a target list of high-risk species. **Ib. High-risk Sites and Survey Methodology** (page 3) identifies and assesses the pathways and high-risk sites through which incipient invasive species enter an island; provides guidance on the number of times areas should be surveyed and the methods to assess them; and creates a timetable for repeatedly surveying the highest-risk sites. **Ic. Prioritizing for Control** (page 7) provides criteria for helping resource managers decide when rapid response is necessary, defines the level of establishment of a given species meriting rapid response, and develops criteria for assessing the level of establishment of given species on an island. **Iid. Targeted Roadside Surveys** (page 10) provides guidance on the number of times areas should be surveyed and the methods to assess them.

### **Iia. Building a Target Species List**

An island-wide early detection methodology is most practically executed using a target-based approach, as opposed to a site-led approach. The first step in building a target list is to gather together a list of all possible candidate taxa for the management unit, then to whittle the list down using various evaluative techniques. This protocol is developed for Hawai‘i, and not all aspects will be applicable to areas outside of the state. Developing a target list can be done in one of two ways: top down or bottom up.

#### **Step 1: Building the List**

##### **i) Top Down:**

- (1) Compile a list of all species documented as established/cultivated on your island.
  - (a) This can be done at the Bishop Museum using their Access database.
    - (i) The database contains all but most recent specimen records that can be retrieved from the Hawaii Biological Survey (HBS) papers, also available at BISH.
- (2) Compile a list of all the known global weeds
  - (a) Includes:
    - (i) U.S. noxious weed lists
    - (ii) All island ISC lists
    - (iii) HEAR weed list
    - (iv) PIER (Pacific Island Ecosystems at Risk) list
    - (v) Global Compendium of Weeds
    - (vi) USGS Noxious Weeds list
    - (vii) Expert interviews
- (3) Cross reference master weed list with all established plants.

- (a) Any unmatched records from weed list will provide you with a list of potential weeds that are not documented as occurring on your island. Incipient weeds will not be included in this list.
- (4) This list will be too large, and must be filtered down.
  - (a) Filters include:
    - (i) Species whose habitat does not occur on your island
    - (ii) Species with low scores on weed risk assessments
    - (iii) Species which have undocumented “weediness”
- (5) This method was rejected for O‘ahu
  - (a) Enough information is known about O‘ahu (extrapolated from research on the island and known potential invasives) that a list can be formed using Bottom Up method

**ii) Bottom Up:**

- (1) Compile lists from weed-tracking agencies:
  - (a) HEAR
  - (b) PIER
  - (c) USGS Federal weed list
  - (d) Hawaii State ISC target lists
  - (e) State and federal noxious weed list
  - (f) Expert interviews from O‘ahu island (field experts who could weigh in on potential targets from their field/personal experience)
- (2) Evaluate and/or survey potential introduction sites on the island
  - (a) “Big Box” nurseries like Home Depot, Kmart, plus smaller retailers
  - (b) Wholesale nurseries
  - (c) Unlisted nurseries: contact info can be obtained from nursery grower associations
  - (d) Off-island nurseries that supply the island
  - (e) Agricultural experimental plots:
    - (i) CTAHR (College of Tropical Agriculture & Human Resources) sites
    - (ii) NFTAL (Nitrogen Fixation in Tropical Agricultural Legumes) sites
  - (f) Botanical Gardens
  - (g) Unregulated plant sources:
    - (i) Swap Meets
    - (ii) Chinatown
  - (h) Known plant enthusiasts:
    - (i) Garden Club members
    - (ii) Hawaiian Botanical Society
  - (i) Community, campus gardens
  - (j) State Department of Education nurseries, City and County nurseries, HDOT plantings
  - (k) Other vector sources:
    - (i) Horse – rodeo / polo boarding of animals
    - (ii) Off-road vehicle areas
    - (iii) Green waste sites

**Step 2: Refining the list:**

- (1) Perform initial assessment (see Appendix A) to:
  - (a) Sort inventoried plant species according to distribution (wide distribution vs. sparing or unknown) on the island, and potential weediness (documented weeds vs. questionably weedy or unlikely weeds).
  - (b) Pull out potential target species (sparingly distributed and documented or suspected weeds)
- (2) Run list of potential target species through WRA (Weed Risk Assessment) to find score: (<http://www.botany.hawaii.edu/faculty/daehler/WRA>) and send list to detection community for review.
- (3) Add high-scoring and recommended species to target list (list should be limited to 150 or fewer species)



### **IIIb. High-risk Sites and Survey Methodology**

The following list describes nine “hot spot” categories for alien plant introduction. These are locations thought to be the most likely sources of new plant introductions to the island, thus providing a starting point for site-led early detection surveys and for developing target species lists. Also described is the type of survey performed in each category, followed by a breakdown of the OED survey effort through June 2007.

1. **Nurseries**—These are split into retail and wholesale nurseries. This type of high-risk site is expected to provide the majority of plants that are a) not ubiquitous and b) show potential for weediness.
  - a. **Retail**—Initially, full, exhaustive inventories were conducted to help familiarize OED staff with many of the common ornamentals. For subsequent nursery surveys, the only species inventoried were those not previously encountered, as well as those that merited targeting or needed further evaluation. An added bonus of retail nursery surveys is that they allow for inventories of stock from off-island wholesale nurseries, backyard growers, and other sources of plants that might otherwise be difficult to survey.

*Site selection:* Starting with a list of all known nursery operations on O‘ahu, OED conducted initial nursery surveys in different regions of the island and are prioritizing future surveys based on an assessment of nursery stock.

*Resurvey interval:* Ideally, retail nurseries would be resurveyed on a biannual basis. However, because of limited time and resources, OED’s strategy will be to prioritize nursery resurveys based on the number of potential targets found on previous surveys, and to revisit those nurseries on an annual basis.
  - b. **Wholesale**—OED will continue to inventory cultivated species that are not yet widely cultivated but are potentially weedy. Some wholesale nurseries specialize in certain taxa (palms, orchids, etc.) but usually advertise a general assortment of tropical ornamentals as well. Some wholesale nurseries may have online inventories from which landscapers and retail nurseries can place orders. Though these are not comprehensive, they may represent a fair sample of the plants at the nursery.

*Site selection:* All known nurseries were identified and surveys were prioritized based on location, types of taxa in stock, and ease of attaining access.

*Resurvey interval:* OED will prioritize resurvey of wholesale nurseries based on the number of potential targets found on previous surveys, and will resurvey on an annual basis. Wholesale nursery resurveys are a higher priority than for retail nurseries, as they often are cultivating species not yet released to general cultivation.
2. **Community Gardens**—Operated by the City and County of Honolulu; the Community Gardens Coordinator should be contacted prior to conducting a survey, as some gardens may have locked perimeter fences. Also, the Coordinator may be able to advise on gardens with the most “diversity” or those with the most input from international sources. Species not already encountered were inventoried, as well as those that merited targeting or needed further evaluation. This site type will likely include ethnic food plants brought in from around the world, which might not be encountered in a nursery survey. *A Tropical Garden Flora* (G. Staples & D. Herbst, 2006, Bishop Museum Press) is an excellent reference for these plants.

*Site selection:* OED surveys were prioritized based on recommendations of the Community Garden Coordinator (Nathan Wong) regarding the gardens with the highest diversity of plants.

*Resurvey interval:* All community gardens should be resurveyed every 2 years.
3. **Botanical Gardens**—These are very large, open site types that are impractical at this time for full inventory. OED’s current strategy is to evaluate species lists from previous surveys of the gardens (performed by Bishop Museum staff), then survey the botanical garden nursery and walk the grounds looking for relatively new additions. In addition to field surveys, inventory lists from the gardens will be obtained and cross-referenced to online weed lists. On-site botanists may also be interviewed regarding those species they identify as being problematic or weedy.

*Site selection:* Site selection was based on habitat and taxa represented in the garden.

*Resurvey interval:* The strategy for Botanical Gardens will be to screen their new accessions on a biannual basis.

4. **Swap Meets, Farmer's Markets, People's Open Markets, Chinatown**—These sites can be expected to contain plants from many sources, including backyard growers, who are a significant source of new plant species that would otherwise be difficult to locate and survey. It should be practical to survey these sites in the same manner as retail or wholesale nurseries.  
*Site selection:* Selection was based on recommendations from experts.  
*Resurvey interval:* These sites can be prioritized and resurveyed on an annual basis.
5. **Agricultural Experimental sites**—Operated by the College of Tropical Agriculture and Human Resources (CTAHR, UH) and the Department of Tropical Plant and Soil Science (TPSS). Wide variety of facilities from open fields to small plots to indoor micro-propagation. Survey style will be site-specific. Species lists could potentially be obtained to pre-screen these sites.  
*Site selection:* Sites were chosen based on what was known to be growing at the stations; those that focused on growing new ornamentals were selected over sites that specialized in a few common agricultural crops.  
*Resurvey interval:* Resurveys of experiment sites can be timed with implementation of new experiments (for example a push to introduce biofuel species), but in general these sites can be prioritized and resurveyed on an annual basis.
6. **Plant sales**—These venues may represent a highly efficient means of surveying for new species, as they are a way for many nurseries to showcase their most recent additions, usually new species and varieties of existing species. These sales are often run on an annual or semi-annual basis and are organized by botanical gardens and societies, as well as nursery associations. In order to conduct a comprehensive survey, it is best to arrange special access before plant fanciers arrive and deplete stock. Survey methods would be as usual.  
*Site selection:* Based on recommendations from experts and timing of the sales.  
*Resurvey interval:* These can be prioritized based on the number of potential targets found on previous surveys. High priority plant sales will be surveyed as they occur.
7. **Historic private estates**—Private plant enthusiasts sometimes import new species, and these importations are less likely to be recorded as acquisitions to a botanical garden. Special access arrangements must be made for each residence. Locating these places is often done through communication with experts.  
*Site selection:* We will be evaluating previous surveys of private estates in order to determine the need for further surveys.  
*Resurvey interval:* These should be prioritized based on based on targets found and resurveyed annually.
8. **Other gardens, including school campuses**—The University of Hawai'i CTAHR website (<http://www.ctahr.hawaii.edu/ctahr2001/>) lists additional gardens that can be found on the island of O'ahu. Some are free public parks and campuses; others are private properties w/ paid admission. Access will need to be arranged on a site-specific basis. Survey style would also be site specific. Larger gardens could be surveyed targeted/opportunistically, while smaller gardens could get a full inventory.  
*Site selection:* Sites were chosen for habitat types and variety of species represented.  
*Resurvey interval:* Gardens that are actively rotating stock will be a higher priority for resurvey on an annual basis.
9. **Large-scale landscaping projects**—New roads, subdivisions, or other large projects can be significant inputs of outer island or other weed species. These species may arrive via heavy equipment from other islands or in hydromulch projects, for example. Tracking these involves coordination with the government agencies involved (Department of Transportation, various housing authorities). Due to the large scale of these projects, surveys would need to be conducted on a targeted/opportunistic basis.  
*Site selection:* This will be based on the scale of the project and whether off-island equipment will be used. OED is working with HDOT to keep informed of large-scale road projects and will be performing both pre- and post- construction surveys.

*Resurvey interval:* One follow up survey 6–12 months later could be done to capture emergent seedlings not present at the initial post-construction survey.

### **IIc. Prioritizing for Control**

The prioritization system developed here is based heavily upon a system created by Susan Timmins and Susan-Jane Owen of the New Zealand Department of Conservation. The system is weed-led, meaning that it aims to control a weedy species at an early stage of establishment. The system uses a six-step process to decide whether a weed can and should be controlled. The steps combine an examination of the species' threat to conservation and/or agriculture with an examination of its controllability, allowing for prioritization of management for species that 1) pose the greatest threats and, based on survey findings and expert interviews, 2) have a currently limited distribution.

#### **Step 1: Initial Assessment** (see Appendix A)

The purpose of the Initial Assessment is to categorize species based on their potential to become invasive in Hawai'i and on their current cultivated and/or naturalized distribution on the island. Species prioritized for control will have a) high potential for invasiveness and b) sparingly cultivated or naturalized status.

Current distribution was determined using the Bishop Museum's herbarium collection and collection databases (<http://www2.bishopmuseum.org/natscidb/>; <http://www2.bishopmuseum.org/HBS/botany/cultivatedplants/>). In addition, *A Tropical Garden Flora* (G. Staples & D. Herbst, 2005, Bishop Museum Press) often provided information not found in the databases or herbarium collection. Species described as “frequently cultivated” or “popular” were categorized as too widespread for targeting. Others described as “rare,” “sparingly cultivated,” or “only found in botanical gardens” were usually categorized as having sparing distributions.

Weed status was determined using online weed lists, an updated Bishop Museum checklist of naturalized plants of Hawai'i, and other resources. An often-used online reference was the Global Compendium of Weeds (<http://hear.org/gcw/>). If a species had unambiguous references to invasiveness in habitats occurring on O'ahu, it was categorized as a weed. If there were ambiguous references (i.e., found on a list of introduced plants) and no other information was found online, it was categorized as a questionable weed. Questionable weeds with sparing distributions were researched further to assess their potential invasiveness. Those exhibiting life history traits such as effective dispersal mechanisms on O'ahu and viable seed were categorized for evaluation by the Hawai'i Weed Risk Assessment (HWRA) and field experts. Species widely cultivated in Hawai'i for over a hundred years with no references to weediness, improbable dispersal mechanisms, and/or lack of viable seed usually received a “no” for weediness, meaning it was improbable they would become invasive.

#### **Step 2: Hawai'i Weed Risk Assessment**

Shahin Ansari of Lyon Arboretum, hired specifically to handle weed risk assessments around the state, performs this portion of the prioritization process. The assessment asks 49 questions relating to the degree and extent of cultivation of the species; climate and distribution; whether it has been recorded as a weed elsewhere; undesirable traits (i.e., thorns, toxicity to animals); what type of plant it is (i.e., aquatic, grass, N-fixing); reproductive mechanisms (whether it hybridizes, is self-compatible); dispersal mechanism (water, wind, bird); and any persistence attributes of the species (prolific seed production, seed bank) in an effort to quantify the species' potential weediness. Expected scores for assessed plants should generally fall between 0 and 29, with 29 being a very high score (e.g., for a species such as *Salvinia molesta*, which displays many weedy tendencies), and 0 being the lower end of the scale for weediness. Some species have scored as low as -13. For more information, you may reference Dr. Curtis Daehler's website at <http://www.botany.hawaii.edu/faculty/daehler/WRA>

#### **Step 3: Assign an “Effect on System” score**

The third step of the process is to assign an “Effect on System” score. This part of the prioritization attempts to capture certain species that may not score high on the WRA but may still have significant ecological impacts on O'ahu or around the state. Again, this score is given by researching the species' behavior either in other areas where it has been introduced or in its native range, where it may display “weedy” characteristics, such as shade tolerance, gap colonization, or a vining habit. Effects on the

composition or regeneration of native communities or on agriculture are ranked on a 0 to 3 scale, with 3 being a major effect, and 0 being no effect. The scores for each impact are totaled. (Table taken from Timmins, S. M., & S. J. Owen, 2001, Scary species, superlative sites: assessing weed risk in New Zealand’s protected natural areas. *In* R. H. Groves, F. D. Panetta, & J. G. Virtue, eds., Weed risk assessment. Collingwood, Australia: CSIRO, pp. 217–227.).

Effect on system	Criteria and Scores			
	0	1	2	3
<b>Composition and structure of terrestrial native communities</b>	Does not affect structurally dominant species.	Minor change in composition of dominant species; little change to basic structure.	Modest effect on composition or structure of community.	Major change to composition or structure of community.
<b>Suppression of regeneration of native species</b>	No significant effect.	Some effect on some species.	Major effect on some species or some effect on dominant species.	Major effect on many species; or major effect on dominant species.
<b>Effect on agriculture</b>	No effect .	Minor effect on agriculture.	Moderate effect.	Major effect- may form dominant stands in pasture or cropland, or have spines or be otherwise unpalatable to herbivores.

**Step 4: Calculate the species’ ‘Weediness Score’ and ‘Weediness Group’**

The Weediness Score is calculated by adding the WRA score to the “Effect on System” score. The final score is used to place the species in a category, with category A having the highest potential for weediness and category D having the lowest\*.

\* The Effect on System score can bump a species’ Weediness Score from an ‘evaluate’ category to ‘targetable’ if it exhibits invasive characters not addressed by the WRA. This effect is similar to the “bump” of the second screening in the WRA (is it a bird-dispersed, shade-tolerant vine?), which can take a species scoring between 0 and 6 and assign a ‘reject’ to them, effectively increasing its score to at least a 7.

**Weediness Score** = Score on WRA (0–29) + “Effect on System” (0–9) score

**Weediness Group:**

A= 26 and up on Weediness Score

B= 17–25

C= 7–16

D= 6 and below

**Step 5: Assess ‘Practicality of Control’**

The next step is to decide how easy it would be to control the known populations of the species in question. This is determined by surveying and by asking experts around O‘ahu.

Initial control cheap, achieve in less than one day, little or no monitoring necessary = **10**

Initial control cheap, achieve in 2–6 days, little or no monitoring needed = **9**

Initial control will take over a week, little or no monitoring needed = **8**

Initial control will take over a week, moderate investment in monitoring = **7**

Initial control will take over a week, monitoring will be intensive = 6  
Species appears to be widespread, based on roadside surveys = 5

**Step 6: Derive a 'Priority Ranking'**

The last step in the process is to determine a Priority Ranking, which acts as a guide as to what action to take. The Priority Ranking is a combination of the Weediness group and the score assigned for Practicality of Control. This final step allows us to use the ranking as a guide to assess the situation, and allows some flexibility in deciding the management recommendation. All control work will be conducted by OISC.

Action to take	Priority Ranking Score
Kill population immediately	A10
High priority for control, assess for immediacy	A7-9, B8-10, C9-10
Control possibly performed; reevaluate after further surveys	A6, B6-7, C7-8, D9-10
Continue surveying for species to map/document	A5, B5, C6, D6-8
Out of project scope	C5, D5

**IId. Targeted Roadside Surveys**

Once OED developed a working knowledge of the variety of introduced plant species present of O'ahu and their invasiveness, and with a target list of incipient invasives in hand, they gradually moved on to concentrate more of their survey effort on roadside monitoring. Forest and Kim Starr were invaluable in teaching survey techniques they developed during road surveys of Maui and Moloka'i. Ideally, a roadside survey for O'ahu would involve driving every road on the island at no more than 5-10 mph. However, that method could take several years to complete, and in any case would be unsafe on roads that cannot be safely traveled at those speeds (i.e., freeways), even during the worst traffic. Prioritizing survey corridors seems the best option, allowing for evaluation of the most effective approaches while working towards a full survey of the island, if possible. Currently, the following potential road survey types are being tested:

1. **Belt roads:** This type of survey would follow the belt roads (Kamehameha Highway and Farrington Highway), which are largely coastal and residential and circumnavigate O'ahu, thus allowing for a quick sample of the entire island. Also included in this category are the major highways such as Pali Highway, Likelike Highway, and the H1, H2, and H3 freeways. Many miles of road could be covered efficiently (no backtracking), but most of these roads cannot be safely traveled at 5-10 mph.
2. **Roads bordering natural areas:** This survey type would prioritize roads based on their proximity to natural areas. For example, a survey of the 'ewa side of Manoa Valley would include Manoa Road, Oahu Avenue, and any side streets bordering natural areas. Tantalus and Round Top Drive border natural areas on both sides. The focus would be on roads and neighborhoods with the highest potential for introduction of cultivated plants to natural areas. It is also an opportunity to survey the borders of natural areas themselves, where adventive or naturalized vs. cultivated status is less ambiguous. Survey rate would be slower (more backtracking and maneuvering), but probably more thorough.
3. **Targeted neighborhoods:** Some neighborhoods are known or reported to have higher-than-average species richness. A survey of this type would involve driving every street within a defined neighborhood hotspot. Some examples would include Wahiawa or Tantalus.
4. **Randomized sampling:** A non-biased approach that could involve gridding out the island, assigning numbers to the grids, and using a random number generator to pick survey areas. It could be combined with a targeted neighborhood approach, as new high-richness areas are encountered.
5. **Military roads:** Some of these are already surveyed by the U.S. Army Natural Resources unit. Others require special access.
6. **4wd roads:** Less-traveled roads could be interesting, especially after Hawaii Superferry operations have begun. This would require a 4-wheel drive-equipped vehicle.

In order to capture the greatest variety of plant species and their distributions on the island, surveys are planned for all major geographic regions, including the windward and leeward, southern and northern



Ko'olau Range, central O'ahu, Waialua/Mokule'ia, and leeward O'ahu. Following the first round of road surveys, sampling frequencies appropriate for different areas will be reassessed.

### **III. RAPID IDENTIFICATION PROGRAM**

The Herbarium Pacificum in Bishop Museum's Department of Natural Sciences is the primary repository for plant vouchers in the State, with over 650,000 catalogued plant specimens. Trained staff taxonomists conduct botanical research and assist with specimen identification as time allows. Botany staff annually provide IDs for hundreds of specimens at the request of a variety of clients, including the State Department of Agriculture; resource management staff for federal, state, and private organizations; and the general public. However, due to resource constraints (e.g., lack of trained staff, lack of dedicated funding devoted to plant ID activities), there has often been a notable time lag in identification and cataloguing of specimens submitted to the Museum, which can jeopardize detection and control efforts that depend on rapid, but well-informed, specimen identification. The hiring of OED staff (Danielle Frohlich, Alex Lau) was designed to address this situation by supplementing BISH Botany staff with additional hired staff dedicated to facilitating and coordinating the timely processing, identification, and cataloguing of potentially invasive species to be vouchered as part of this project. Primarily assisting in the taxonomic training of OED staff at BISH were plant taxonomists Drs. George Staples and Derral Herbst. Weekly plant identification sessions were held in the herbarium with Botany staff to improve their abilities to identify plant families.

A one-week traveling tropical plant identification course taught by botanists from the prestigious Royal Botanic Gardens, Kew, was brought to Herbarium Pacificum in July–August 2007. Travel expenses were supported by fees charged to 20 participants representing a wide range of organizations in Hawai'i with resource management field staff. All Herbarium Pacificum staffers also participated, including OED staff. The course proved instrumental in helping participants understand the suites of plant characters that distinguish major plant families, always an critical step in identifying an unknown plant.

OED serves as the coordinating entity at the Museum for vouchering and tracking the progress of targeted non-native specimens through all stages of herbarium processing, a primary goal being to facilitate identification and timely information turnaround to the ISCs and other weed management units so that they can make informed management decisions. OED tracks their own collections as well as certain specimens submitted to the museum from throughout the state (See Appendix D). Among submitted specimens being tracked are new naturalized records and incipient invasive species. Although the process has not yet been solidified, in the future all incipient non-native specimens will be tracked by OED. Combining the number of species listed in OED's High-risk Species List (Appendix B) and the Specimen Identification Inventory (Appendix D), over 1,380 species have been identified and catalogued. In addition, PBIN is working with OED to ensure that all information collected and tracked adheres to statewide data standards and protocols for eventual use in a statewide database for tracking and assessing species establishment in Hawai'i.

On occasion, specimens are collected that resist ready identification, perhaps because the Herbarium Pacificum does not have comparative material, or no available taxonomic keys satisfactorily identify it. In such cases, a taxonomic expert elsewhere is sought out, and a specimen is sent by mail if that person agrees to examine it. This process includes a built-in bottleneck of varying length due to time involved in shipping, as well as work commitments of the identifier. OED is helping to facilitate the streamlining of this process by seeking out taxonomic experts, obtaining permissions, preparing the loan/gift specimens to be sent, and tracking the status of the ID request. Herbarium Pacificum has an in-house list of specialist taxonomists that have been consulted in the past that OED can refer to, but OED also uses its initiative to consult other, perhaps more contemporary, specialists. In at least one case, a photo ID confirmation of *Topobea parasitica* was made online by melastome taxonomist Dr. Darin Penneys of the University of Florida.

Currently, OED is participating in-house effort, in coordination with collections staff, to identify a several year old backlog of vouchers submitted by collectors on Maui and the Big Island. The determinations, some of which record novelties to the state or an island, are then promptly mailed to the collectors. Identification of these outer island specimens introduces a future phase of the program in which OED might serve as a clearinghouse for plant ID requests from throughout the state.

#### IV. O'AHU EARLY DETECTION PROGRAM

The O'ahu Early Detection (OED) program is an ongoing on-the-ground test of the Detection Plan Model on O'ahu. Between July 2006 and July 2007, OED surveyed about 30 plant establishments, including over 15 commercial and retail nurseries, 4 botanical gardens, and a variety of community gardens, agricultural research facilities, and farmer's markets. As comprehensive early detection is a daunting task, implementation of the OED program on O'ahu is envisioned as taking place over a three-year period. Thus, not many species were recommended for control in the first year, outside of those encountered in Botanical Gardens, where likelihood of their distribution to general cultivation is low. Species recommended for control thus far include *Parkinsonia aculeata*, *Piper aduncum*, and *Topobea parasitica* (see Appendix C for species profiles).

Highlights of OED surveys thus far include a target list of 133 high-risk species (see Appendix B for a complete list), and 12 new naturalized weed records for the state and 13 others for O'ahu. About 300 plants have been identified for U.S. Army Natural Resources, OISC, Maui Land & Pine, and USGS. New findings were published in Bishop Museum's Records of the Hawaii Biological Survey in October 2007 [Frohlich, D. & A. Lau. 2007. New plant records from O'ahu for 2006. *Bishop Museum Occasional Papers* 96: 8–13]. OED has also participated in a Herbarium Pacificum botanical resource survey of Board of Water Supply property in Waihe'e and Kahalu'u Valleys in windward O'ahu, where they searched for incipient invasive species jumping the fence line from nearby home gardens. Appendices B (High-risk Species List), C (Species Profiles), and D (Specimen Identification Inventory) help to document their first-year efforts.

#### Distribution of Survey Effort

Nurseries comprise 65% of the high-risk site list compiled by OED and are a significant source of new species to the island. Most other high-risk sites represent fractions of a percent of total sites, but in the interest of sampling every site type these will get a disproportionately larger percentage of total surveys. To compensate, wholesale nursery inventory lists were also evaluated, bringing the number of total species inventoried at nurseries to around 65%. High-risk sites were researched using telephone directories, the internet, and various reports. There are likely to be many more nurseries and small gardens on O'ahu than have been identified.

Type of site	Total number	Number surveyed
Retail Nurseries	34	9
Wholesale Nurseries	70	10 (6 nursery visits + 4 inventory lists)
Community Gardens	10	3
Botanical Gardens	7	3
Campus/Other Garden	18	4
Swap Meets	2	1
Farmer's Markets	Many	1
Chinatown	1	1
Ag. Experimental Sites	4	2
Plant Sales	5	1
Private Estates	Many	0

Site visited	Date
Foster Botanical Garden	8/17/2006
Home Depot, Iwilei	9/7/2006
Wally's	9/14/2006
Kaneohe Community Garden	10/6/2006

Site visited	Date
Ko'olau Farmers, Kaneohe	10/9/2006
Makiki Community Garden	10/11/2006
Sharon' s Plants	10/24/2006
Leilani Nursery	10/25/2006
Walmart, Mililani	10/31/2006
Kilgo's	11/3/2006
Koko Crater Botanical Garden	11/4/2006
R+S Ni'i Nursery	11/8/2006
Akamai Landscaping	11/10/2006
Kmart, Kapolei	11/15/2006
Magoon Greenhouse	11/21/2006
The Plant Place	11/28/2006
Waimanalo Agricultural Station	11/30/2006
Walmart, Waipahu	12/5/2006
Waimea Audubon Center	12/7/2006
Makiki Arboretum Trail	12/16/2006
Kapiolani Community College Garden	3/10/2007
Frankie's Nursery	3/23/2007
Lyon Arboretum	4/24/2007
Landscape Industry Council of Hawaii Conference	5/16/2007
Oahu Nursery Growers Association Plant Sale	6/16/2007
Pearl City Urban Garden Center	8/30/2007
Waihale Products	10/5/2007

As of mid-June 2007, OED had already surveyed 212 miles of road in 14 neighborhoods (see Fig. 1).

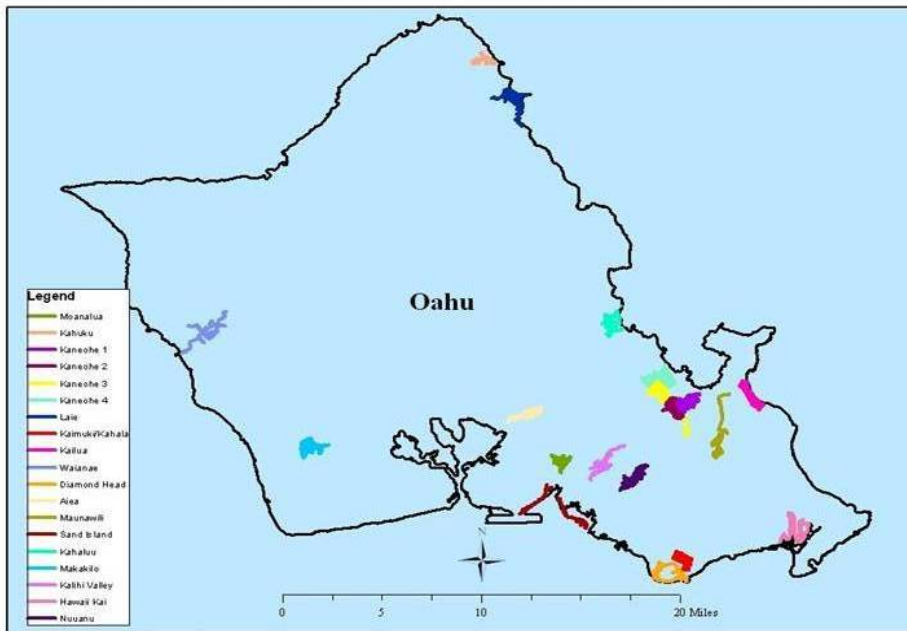


Figure 1: Map showing roads de surveys to date

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Education/Outreach: Efforts were made to increase public awareness of the importance of early detection through community outreach and public presentations. One of the hoped-for benefits is an increase in public reporting of potential invasive plant pests. The following is a summary of education and outreach activities associated with the program.

- Outreach to Detection Community <http://www.hear.org/oisc/oahuearlydetectionproject/>
- KHNL news report <http://www.khnl.com/Global/story.asp?S=5822678>
- Ka 'Elele Spring 2007 article <http://pagebang.com/cgi/nph-proxy.cgi/111011A/http/www.bishopmuseum.org/membership/kaelele/KaElele.pdf>
- Bishop Museum website media page <http://www.bishopmuseum.org/media/2006/pr06073.html>
- DLNR DOFAW Na Leo o ka 'Aina Winter 2007 Newsletter <http://www.state.hi.us/dlnr/dofaw/newsletter/newsletter%20winter%2007.pdf>
- O'ahu Nursery Grower's Association meeting
- Waimanalo Agricultural Association meeting
- Nursery/Arboretum/CTAHR/Plant sale visits (interaction with owners)
- Presentation to David Bakke, USDA FS rep
- 2006 Hawai'i Conservation Conference, plant collection workshop, July 2006
- Consulting with Kristin Hall/Kaua'i Invasive Species Committee, on Kaua'i's early detection program, August 2006
- Linda Lingle listening session, September 2006
- Max Suckling Biosecurity forum, September 2006
- Jumping the Fenceline seminar, October 2006
- Ken Ching and USDA inspections
- OISC Photo ID workshop
- Established Pest Working Group meeting
- 2007 Hawai'i Conservation Conference, poster presentation, July 2007





**Figure 1.** Danielle Frohlich inventorying plants at the Waipahu Walmart nursery.



**Figure 4.** Alex and Rich Criley at Magoon Laboratory, next to a tree *Pyracantha*.



**Figure 2.** Danielle pressing a specimen of *Medinilla* at Bishop Museum.



**Figure 5.** Danielle with Frank Sekiya, owner of Frankie's Nursery in Waimanalo.



**Figure 6.** *Topobea maurofernandeziana*, potentially invasive melastome, Lyon Arboretum.



**Figure 3.** Alex Lau with University of Hawai'i horticulture professor Rich Criley, Magoon Laboratory.

Note: All photos (Figures 1–12) taken by OED staff.





**Figure 7.** Danielle participating in Kew Gardens Tropical Plant Identification course at Herbarium Pacificum, with instructor Dr. Tim Utteridge (R) and Dr. Shelley James (L).



**Figure 10.** Danielle and Clyde Imada (BISH) at Koko Crater Botanical Garden.



**Figure 8.** Danielle with Carl Okuda of the Pearl City Urban Garden Center.



**Figure 11.** Danielle & Alex at Waihe'e, along with Micah Ryder (KMWP) and Barb Kennedy (BISH).



**Figure 9.** A plant sale sponsored by the Oahu Nursery Growers Association.



**Figure 12.** Naturalizing *Medinilla magnifica* found during the Waihe'e survey.

## Appendix A: Initial Assessment

1. Is it a documented weed anywhere?
  - a. Yes—go to 2
  - b. No—Add to list of species less likely to be weeds (not documented anywhere as weedy despite wide/long term cultivation, combined with documentation that it is not a weed) (List E).
  - c. Not documented, but still possibly a weed (based on biological characteristics, or species is new to cultivation)—go to 5
2. Is it widely cultivated or sold on O‘ahu?
  - a. Yes—go to 3
  - b. No—go to 4
  - c. Not sure how widely cultivated; ask cultivated plant experts about distribution—Add to list A3.
  - d. Not cultivated, grows as a weed in pots of cultivated plants or in yards—Add to list D.
3. Is it well documented as naturalized on O‘ahu?
  - a. Yes—Add to list of species to recommend against selling/cultivating (List B3).
  - b. No—Consider mapping the distribution; add to list of species to recommend against selling/cultivating (List B2).
4. Is it naturalized beyond targeting on O‘ahu?
  - a. Yes—Add to list of species to recommend against selling/cultivating (List B1).
  - b. No—Add to list of potential targets (List A1).
  - c. Not sure about degree of establishment—Add to list of species to be evaluated by Field experts (List A3).
    - i. Field experts believe species is naturalized beyond targeting—Add to List B1.
    - ii. Field experts believe species is still a potential target—Add to List A1.
5. Is it widely cultivated on O‘ahu?
  - a. Yes—Add to Watch list (List C2).
  - b. No—go to 6
6. Is there strong biological, ecological, or other reason to believe the species could be invasive?
  - a. Yes—Add to List A2. Send these species for screening by HWRA. Also send off to Field experts for invasive information, distribution, and comments.
    - i. HWRA/Experts indicate it is invasive and not naturalized beyond targeting on O‘ahu—Add to List A1.
    - ii. HWRA/Experts indicate it is invasive but naturalized beyond targeting on O‘ahu—Add to List B1.
    - iii. HWRA/Experts indicate it is less likely to be invasive—Add to Watch list (List C1).
  - b. No—Add to Watch list (List C1).

### List types:

#### A – Potential target list

**A1:** These species are documented and/or known weeds, have not been documented as naturalized on O‘ahu, and are only sparingly cultivated here. These species are candidates for the Early Detection target list, pending evaluation by the HWRA and review by field experts (*Piper aduncum*, *Acacia auriculiformis*, *Parkinsonia aculeata*, *Pereskia aculeata*).

**A2:** These species are more sparingly cultivated on O‘ahu, are not documented as invasive or naturalized, but have biological, ecological, or other characteristics that suggest they could be invasive. They should be evaluated by the HWRA (invasive potential) and by Field experts (invasiveness and distribution) (*Medinilla scortechinii*, *Schefflera elegantissima*, *Murraya koenigii*).

**A3:** These species are documented as weeds, and their distribution, either in cultivation or their naturalized status, is unclear. These species will be sent to cultivated plant/field experts to



determine their distribution. These are potential targets, pending distribution information (*Jatropha curcas*, *Vigna speciosa*, *Myrciaria cauliflora*).

**B – Recommend against cultivation**

**B1:** These species are documented weeds that are naturalized beyond targeting on O'ahu, and are sparingly cultivated here. We recommend these species be phased out of cultivation (*Azolla filiculoides*, *Cissus verticillata*).

**B2:** These species are documented as weeds elsewhere and are widely cultivated on O'ahu, but have not been documented as naturalized here. Some are actually naturalized, but simply need to be vouchered. We recommend these species be phased out of cultivation here, and closely monitored for signs of invasiveness (*Eugenia uniflora*, *Syngonium podophyllum*).

**B3:** These species are documented as invasive, including on O'ahu, but are still widely cultivated here. We recommend these species be phased out of cultivation (*Schefflera actinophylla*, *Psidium cattleianum*).

**C – Watch List**

**C1:** These species are more sparingly cultivated or distributed on O'ahu and are not documented as invasive or naturalized, but have some potential to be weeds. They are less likely to be invasive based on their biology, ecology, and/or field observations. They will be monitored in the future for signs of invasiveness (*Polyalthia longifolia* subsp. *pendula*, *Stigmaphyllon floribunda*).

**C2:** These species are more widely cultivated on O'ahu and are not documented as invasive or naturalized, but have some potential to be weeds based on biological/ecological characteristics such as a current lack of specialist pollinator, or current lack of efficient dispersal mechanism. They will be monitored in the future for signs of invasiveness (*Ficus elastica*, *Arachis pintoi*, *Plumeria rubra*, *Spondias dulcis*).

**D:** Too widespread to target, not cultivated: These species are rarely if ever cultivated and are more often growing in pots or yards as weeds. They are too well distributed for targeting, and their eradication is improbable (*Youngia japonica*, *Cardamine flexuosa*, *Ageratum conyzoides*).

**E:** Not likely to be weedy: These species are not documented as weeds elsewhere, and based on their biology, ecology, HWRA score, and/or field expert review they exhibit little potential to be invasive. These species should be monitored by their growers for signs of spreading (*Ananas comosus*, *Artocarpus altilis*, *Fagraea berteriana*).

## Appendix B: High-risk Species List

The following alphabetical list of 133 taxa comprise OED's targeted high-risk incipient weed list for O'ahu (as of October 2007). Whittled down from more than 1,000 candidates, these taxa emerged from the evaluative protocols outlined in this report as the top target species for OED's O'ahu surveys. If encountered, management recommendations would be derived using protocols in **IIc. Prioritizing for Control** (p. xx). O'ahu Early Detection profiles of three of these species follow in Appendix C.

Scientific Name	Family	Common Name(s)
<i>Acacia auriculiformis</i>	Fabaceae	Darwin black wattle, ear-leaf acacia
<i>Acacia mangium</i>	Fabaceae	Mangium, mangium wattle
<i>Acacia mearnsii</i>	Fabaceae	Black wattle, tan wattle, Australian acacia
<i>Acacia melanoxylon</i>	Fabaceae	Australian blackwood, blackwood acacia
<i>Acacia parramattensis</i>	Fabaceae	Parramatta green wattle, Sydney green wattle
<i>Acacia pennata</i> subsp. <i>insuavis</i>	Fabaceae	Cha-om
<i>Acacia podalyriifolia</i>	Fabaceae	Queensland silver wattle, pearl wattle
<i>Acacia retinodes</i>	Fabaceae	Water wattle, swamp wattle.
<i>Acacia saligna</i>	Fabaceae	Coojong
<i>Acca sellowiana</i>	Myrtaceae	Pineapple guava, feijoa, guavasteen
<i>Adenantha pavonina</i>	Fabaceae	False wiliwili
<i>Ailanthus altissima</i>	Simaroubaceae	Chinese sumac, Chinese tree of heaven
<i>Artabotrys hexapetalus</i>	Annonaceae	Climbing ylang-ylang, ylang-ylang
<i>Arundo donax</i>	Poaceae	Giant reed, Spanish reed, giant cane
<i>Bassia hyssopifolia</i>	Chenopodiaceae	Bassia, five-hook bassia, thorn orache
<i>Bauhinia vahlii</i>	Fabaceae	Malu creeper
<i>Bocconia frutescens</i>	Papaveraceae	Bocconia
<i>Buddleja davidii</i>	Buddlejaceae	Butterfly bush
<i>Buddleja madagascariensis</i>	Buddlejaceae	Smoke bush
<i>Centranthus ruber</i>	Valerianaceae	Red valerian
<i>Chromolaena odorata</i>	Asteraceae	Bitter bush, Christmasbush, chromolaena
<i>Cinchona pubescens</i>	Rubiaceae	Quinine tree, red cinchona
<i>Cinnamomum verum</i>	Lauraceae	Cinnamon
<i>Clerodendrum quadriloculare</i>	Verbenaceae	Bronze leaf clerodendrum, Philippine glorybower
<i>Cordia alliodora</i>	Boraginaceae	
<i>Cortaderia jubata</i>	Poaceae	Pampas grass, Jubata grass
<i>Cortaderia selloana</i>	Poaceae	Pampas grass
<i>Corynocarpus laevigatus</i>	Corynocarpaceae	Karaka nut
<i>Cotoneaster pannosus</i>	Rosaceae	Silverleaf cotoneaster
<i>Cryptostegia grandiflora</i>	Asclepiadaceae	Rubbervine
<i>Cryptostegia madagascariensis</i>	Asclepiadaceae	Rubbervine
<i>Cytisus palmensis</i>	Fabaceae	Tagaste, tree lucerne, escobon
<i>Delairea odorata</i>	Asteraceae	African ivy, Cape ivy
<i>Derris elliptica</i>	Fabaceae	Tubaroot, derris
<i>Dorstenia contrajerva</i>	Moraceae	Contra yerba
<i>Doyyalis hebecarpa</i>	Flacourtiaceae	Ceylon gooseberry
<i>Eichhornia crassipes</i>	Pontederiaceae	Water hyacinth

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Scientific Name	Family	Common Name(s)
<i>Enchylaena tomentosa</i>	Chenopodiaceae	Ruby saltbush
<i>Equisetum arvense</i>	Equisetaceae	Field horsetail
<i>Eustrephus latifolius</i>	Smilacaceae	Bamboo vine
<i>Euterpe oleracea</i>	Arecaceae	Acai
<i>Ficus religiosa</i>	Moraceae	Bo tree
<i>Flueggea virosa</i>	Euphorbiaceae	Chinese waterberry
<i>Gaura lindheimeri</i>	Onagraceae	Gaura
<i>Hibiscus makinoi</i>	Malvaceae	Sakishima cottonrose
<i>Hiptage benghalensis</i>	Malpighiaceae	Hiptage
<i>Hura crepitans</i>	Euphorbiaceae	Sandbox tree
<i>Hypericum canariense</i>	Clusiaceae	Canary Islands St. Johnswort
<i>Imperata cylindrica</i>	Poaceae	Cogon grass, imperata
<i>Ipomoea carnea</i>	Convolvulaceae	Bush morning glory
<i>Jatropha curcas</i>	Euphorbiaceae	Physic nut
<i>Jatropha gossypifolia</i>	Euphorbiaceae	Bellyache bush
<i>Leea indica</i>	Leeaceae	Kalet
<i>Leptospermum scoparium</i> cv. Double Form	Myrtaceae	Manuka
<i>Leycesteria formosa</i>	Caprifoliaceae	Himalayan honeysuckle
<i>Ligustrum lucidum</i>	Oleaceae	Glossy privet
<i>Ligustrum sinense</i>	Oleaceae	Chinese privet
<i>Lonicera japonica</i>	Caprifoliaceae	Japanese honeysuckle
<i>Medinilla crassata</i>	Melastomataceae	Medinilla 'Lalique'
<i>Medinilla cumingii</i>	Melastomataceae	
<i>Medinilla magnifica</i>	Melastomataceae	Magnificent medinilla
<i>Medinilla scortechinii</i>	Melastomataceae	
<i>Medinilla</i> sp.	Melastomataceae	
<i>Medinilla venosa</i>	Melastomataceae	Holdtight
<i>Melastoma sanguineum</i>	Melastomataceae	Fox-tongue melastoma
<i>Melochia umbellata</i>	Sterculiaceae	Melochia
<i>Merremia peltata</i>	Convolvulaceae	
<i>Metrosideros excelsa</i>	Myrtaceae	Pohutukawa
<i>Metrosideros kermadecensis</i>	Myrtaceae	Reverse-variegated ohia haole
<i>Miconia calvescens</i>	Melastomataceae	Miconia
<i>Mikania micrantha</i>	Asteraceae	Mikania, American rope
<i>Mimosa invisa</i>	Fabaceae	Giant sensitive plant
<i>Morella cerifera</i>	Myricaceae	Wax myrtle
<i>Morella faya</i>	Myricaceae	Fire tree
<i>Mucuna pruriens</i>	Fabaceae	Velvet bean, cowhage
<i>Odontonema tubiforme</i>	Acanthaceae	Purple firespike
<i>Olea europaea</i> var. <i>cuspidata</i>	Oleaceae	African olive
<i>Omalanthus populifolius</i>	Euphorbiaceae	Bleeding heart tree
<i>Parkinsonia aculeata</i>	Fabaceae	Jerusalem thorn
<i>Passiflora mollissima</i>	Passifloraceae	Banana poka
<i>Passiflora quadrangularis</i>	Passifloraceae	Giant granadilla



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Scientific Name	Family	Common Name(s)
<i>Passiflora vitifolia</i>	Passifloraceae	Grape-leaved passion flower,
<i>Paulownia tomentosa</i>	Scrophulariaceae	Empress/Princess tree, foxglove tree
<i>Pennisetum setaceum</i>	Poaceae	Fountain grass
<i>Pereskia aculeata</i>	Cactaceae	Barbados gooseberry
<i>Pereskia bleo</i>	Cactaceae	Bleo
<i>Pereskia grandifolia</i>	Cactaceae	Rose cactus
<i>Pereskia grandifolia</i> var. <i>grandifolia</i>	Cactaceae	Rose cactus
<i>Pereskia lychnidiflora</i>	Cactaceae	
<i>Philadelphus karwinskyanus</i>	Hydrangeaceae	Philadelphus
<i>Phormium tenax</i>	Agavaceae	New Zealand hemp, New Zealand flax
<i>Phytolacca dioica</i>	Phytolaccaceae	Ombu
<i>Piper aduncum</i>	Piperaceae	Spiked pepper
<i>Piper auritum</i>	Piperaceae	False 'awa
<i>Pittosporum undulatum</i>	Pittosporaceae	Victorian box, Australian cheesewood
<i>Pittosporum viridiflorum</i>	Pittosporaceae	Cape pittosporum
<i>Platymiscium stipulare</i>	Fabaceae	
<i>Prosopis juliflora</i>	Fabaceae	Long-thorn kiawe
<i>Pseudogynoxys chenopodioides</i>	Asteraceae	Mexican flame vine
<i>Pueraria montana</i> var. <i>lobata</i>	Fabaceae	Tropical kudzu
<i>Pyracantha angustifolia</i>	Rosaceae	Narrow-leaved firethorn
<i>Pyracantha crenatoserrata</i>	Rosaceae	Firethorn
<i>Pyracantha koidzumii</i>	Rosaceae	Koidzumi's firethorn
<i>Rosa multiflora</i>	Rosaceae	Multiflora rose
<i>Rubus</i> spp.	Rosaceae	
<i>Saccharum spontaneum</i>	Poaceae	Wild sugarcane
<i>Salsola tragus</i>	Chenopodiaceae	Tumbleweed
<i>Salvinia molesta</i>	Salviniaceae	Kariba weed
<i>Schefflera insularum</i>	Araliaceae	
<i>Schizachyrium condensatum</i>	Poaceae	Bush beardgrass
<i>Semecarpus nigroviridis</i>	Anacardiaceae	Marking nut tree
<i>Senecio madagascariensis</i>	Asteraceae	Fireweed
<i>Setaria sphacelata</i>	Poaceae	African bristlegrass
<i>Stachytarpheta mutabilis</i>	Verbenaceae	Changeable vervain
<i>Tamarix aphylla</i>	Tamaricaceae	Athel tamarisk
<i>Tamarix parviflora</i>	Tamaricaceae	Tamarisk
<i>Tetrastigma lanceolarium</i>	Vitaceae	
<i>Tetrastigma pubinerve</i>	Vitaceae	
<i>Tetrastigma voinieranum</i>	Vitaceae	Lizard plant
<i>Tetrazygia bicolor</i>	Melastomataceae	Florida clover ash
<i>Tibouchina granulosa</i>	Melastomataceae	Glory tree
<i>Tibouchina herbacea</i>	Melastomataceae	Cane tibouchina
<i>Tibouchina longifolia</i>	Melastomataceae	Longleaf glorytree
<i>Tipuana tipu</i>	Fabaceae	Rosewood, Pride of Bolivia
<i>Topobea maurofernandeziana</i>	Melastomataceae	

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<b>Scientific Name</b>	<b>Family</b>	<b>Common Name(s)</b>
<i>Topobea parasitica</i>	Melastomataceae	
<i>Trichostigma peruvianum</i>	Phytolaccaceae	
<i>Ulex europaeus</i>	Fabaceae	Gorse
<i>Urtica urens</i>	Urticaceae	Dwarf nettle
<i>Vernonia elliptica</i>	Asteraceae	Climbing vernonia
<i>Vigna speciosa</i>	Fabaceae	Snail vine, Snail maunaloa
<i>Vitex agnus-castus</i>	Verbenaceae	Chaste tree
<i>Washingtonia robusta</i>	Areaceae	Mexican washingtonia

## Appendix C: Species Profiles

*Parkinsonia aculeata*

Common name: Jerusalem thorn

Family: Fabaceae

Excerpt from a report prepared by: Forest Starr, Kim Starr, and Lloyd Loope, U. S. Geological Survey—  
Biological Resources Division, Haleakala Field Station, Maui, Hawai‘i



Infestation of Parkinsonia (*Parkinsonia aculeata*) (yellow flowering shrub) in the catchment of the Burdekin River in Australia (photo: Roger Lawes, CSIRO)

### OVERVIEW

Jerusalem thorn (*Parkinsonia aculeata* L.) is a shrubby, thorny tree similar to kiawe (*Prosopis pallida*). It is widely cultivated and is known to spread from initial plantings in North America as far north as California, Arizona, and Florida, the West Indies, Australia, Hawai‘i, Guam, and Micronesia (DNR 1998; PIER 2000; Wagner et al. 1999). In Australia, it forms impenetrable thickets along watercourses, and seeds spread downstream to cause further infestations. On O‘ahu, *P. aculeata* is confirmed in only two locations, but has been planted historically in several other, now well-developed locations, which should be surveyed for potentially persisting populations. Eradication of all known populations of this species, surveys of historical planting sites, and further exclusion from O‘ahu could potentially save time and money.

### DESCRIPTION

“Shrubby trees 3-10 m tall, bark green, smooth; branches armed with strong spines of stipular or leaf rachis origin. Leaves with primary rachis spine-like, with 1–3 congested pairs of pinnae, secondary rachises green and flattened, leaflets 14–40 pairs, distinctly scattered, elliptic to narrowly obovate, 2–10 mm long, 1–4 mm wide. Flowers 2–3 cm in diameter, in racemes shorter than the pinnae; calyx lobes 4–6 mm long, reflexed; corolla yellow, 10–14 mm long, arose, claws ca. 1/2 as long as limbs. Pods linear-cylindrical, 5–20 cm long, 0.6–1 cm wide, strongly constricted between the seeds. Seeds greenish mottled with brown or purple, 1–6, ellipsoid-ovoid, 8–10 mm long, 4–6 mm wide.” (Wagner et al. 1999).

### BIOLOGY & ECOLOGY

**Cultivation:** *Parkinsonia aculeata* is a hardy species valued as an ornamental or shade tree. Its uniquely-shaped leaves, pretty yellow flowers, shrubby weeping habit, drought tolerance, and ability to grow in a wide range of soils makes it an appealing tree to grow. Jerusalem thorn has also been used in areas of Africa and Pakistan to revegetate desert regions (Floridata 2001).

**Invasiveness:** *Parkinsonia aculeata* has spread throughout the world as an ornamental tree and has since escaped from cultivation in areas where it is planted. It is fast-growing, drought tolerant, and able to grow in different soil types. In Australia, *Parkinsonia* can form dense, thorny, impenetrable thickets along

watercourses and drainages. Jerusalem thorn can produce from 5,000 to 13,000 seeds that float downstream to cause further infestation (DNR 1998).

**Pollination:** Unknown.

**Propagation:** *Parkinsonia aculeata* seeds have a thick coat and propagate best when soaked. The hard coating allows the seeds to remain viable for many years as they await ideal germination conditions (DNR 1998). Two types of seeds are reported to be produced by *P. aculeata*: 25% of the seeds are light brown and will germinate right away, while the remaining light and dark brown seeds need scarification or soaking to induce germination (Floridata 2001).

**Dispersal:** *Parkinsonia aculeata* seeds disperse via watercourses and flood conditions. It is also dispersed by animals and humans.

**Pests and Diseases:** Few pests and diseases are reported, though two beetles and one bug have been introduced to Australia for potential biological control.

## DISTRIBUTION

**Native range:** There is some confusion over the native range of *Parkinsonia aculeata*. In the Galapagos, this species is considered native, though some scientists suspect it could be a more recent arrival. In addition, there seems to be some confusion about its native range in other areas of tropical America. For instance, Wagner et al. (1999) include the West Indies as part of the native range; however, other sources (Floridata 2001) consider this species to be an escape from cultivation in that area. In addition, Wagner et al. (1999) cite *P. aculeata* as escaped in Arizona, California, and Florida, while other sources (Floridata 2001) list it as native to the desert grasslands and canyons in Mexico and the southwestern United States, where it grows in association with mesquite (*Prosopis pallida*).

**Global distribution:** *Parkinsonia aculeata* is documented as widely cultivated and is known to spread from initial plantings in California, Arizona, Florida, the West Indies, Australia, Hawai'i, Guam, and Micronesia (DNR 1998; PIER 2000; Wagner et al. 1999). In Australia, *P. aculeata* has been given the designation Weed of National Significance. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Economic costs to landholders stem from an increased difficulty in mustering stock, a reduction in stock access to watering points, and a decrease in primary production of grasses that are replaced by *P. aculeata*. Additionally, *P. aculeata* infestations provide refuges for feral animals, especially pigs.

The environmental impacts of *Parkinsonia aculeata* are numerous. Native plant species are replaced, leading to lower quality habitat for animals. Wetlands are particularly vulnerable because *P. aculeata* can dam watercourses, cause erosion, lower water tables, and take over vast tracts of floodplain.

**State of Hawai'i distribution:** In Hawai'i, *Parkinsonia aculeata* is naturalized on Kaua'i, O'ahu, and Maui (Wagner et al. 1999). Population structure on Kaua'i and O'ahu is not yet known.

**Island of O'ahu distribution:** There are two confirmed sites on O'ahu where *Parkinsonia aculeata* has been intentionally planted, as well as an additional unconfirmed site where it has been historically documented. The two confirmed sites are Waimea Botanical Garden, on the north shore of the island, and Koko Crater Botanical Garden, in southeastern O'ahu. The historically documented site is on Sand Island, where *P. aculeata* was last collected in 1936. It is recommended that this area be surveyed to assess the status of this species in the area.

## CONTROL METHODS

### Physical control:

**Hand pulling:** Small seedlings and juveniles can be hand pulled, taking care not to injure oneself on the thorns.

**Bulldozing:** Bulldozing has been used successfully to control *P. aculeata* in Pu'unene on the island of Maui. In Australia (DNR 1998), blade plowing or ripping has been found to be effective, though it can only

be done in level areas away from watercourses. In addition, follow-up is crucial to total control, as disturbance often leads to subsequent seed germination.

*Fire:* With a sufficient fuel load, fire can kill smaller seedlings; however, adult plants will usually survive (DNR 1998).

**Chemical control:**

Seedlings can be controlled using triclopyr in foliar spray methods. Basal bark and cut stump treatments with triclopyr are also listed as effective in Australia (DNR 1998). On Maui, trees were controlled with a cut stump method using Garlon 3A. Follow the label for any chemical treatments. The Queensland Department of Natural Resources suggests the following for chemical control of *Parkinsonia aculeata*:

*Foliar (overall) spray:* A very effective control method for seedlings up to 1.5 m tall. Spray leaf and stems to point of runoff. A wetting agent (2ml/L of spray mixture) must be used. Trade name of herbicide is Grazon DS. Active chemicals are picloram & triclopyr. Suggested rate of application is .35L/100L water. For foliar spray using Grazon DS, Western Agriculture Australia suggests a rate of dilution of 1:50 in distillate (Agriculture Western Australia 1998).

*Aerial application by helicopter:* For plants up to 1.5 m in large stands or inaccessible terrain. Best results when plants are flowering. Addition of 1L/ha of Uptake wetting agent. Trade name of herbicide is Grazon DS. Active chemicals are picloram and triclopyr. Suggested rate of application is 3L/ha.

*Basal bark:* Effective for stems up to 15 cm diameter, carefully spray completely around base of plant to a height of 30 cm above ground level. Larger trees may be controlled by spraying to a greater height, up to 100 cm above ground level. Plants should be actively growing and preferably flowering. Field experience has shown that good soil moisture is essential for effective control. In areas that are subject to flooding care is needed to ensure that mud and flood debris does not prevent spray penetration. The trunk may be needed to be cleared before application. Trade name of herbicide is Garlon 600. Active chemical is triclopyr. Suggested rate of application is 1L/60L diesel. Also suggested for stems up to 5 cm is an herbicide with the trade name Access. Active chemicals are Triclopyr and Picloram. Suggested rate of application is 1L/60L diesel. For basal bark treatment using Garlon 600, Western Agriculture Australia suggests a rate of dilution of 1:60 in distillate (Agriculture Western Australia 1998).

*Cut stump:* May be performed any time of year. Cut stems horizontally as close to the ground as possible. Immediately (within 15 seconds) swab cut surface with herbicide mixture. Trade name of suggested herbicide is Access. Active chemicals are triclopyr & picloram. Suggested rate of application is 1L/60 L diesel.

*Soil application:* Not recommended for areas near desirable trees or near watercourses. Use one dose of herbicide per meter of tree height. Place doses close to tree trunk, either with spot gun on clear bare ground, or underground with ground injector. Rain or sufficient soil moisture is required before herbicide is taken up by the plant. Trade name of herbicide is Velpar L. Active chemical is hexazinone (via spotgun). Suggested rate of application is 4 ml/m height.

**Biological control:** In Australia, three biological organisms have been introduced to try to reduce the invasion of Jerusalem thorn: two seed beetles (*Penthobruchus germani* and *Mimosestes ulkei*), which attack the mature seeds; and one leaf bug (*Rhinacloa callicrates*), which feeds on the leaves and shoots (DNR 1998). While all three insects have established at release sites, *Penthobruchus germani* is currently the most effective at establishing and attacking seeds of *Parkinsonia aculeata*.

**Cultural control:** To prevent spread of this thorny plant, do not propagate, plant, or distribute it. Prevention seems to be the best option, as this plant seems to escape wherever planted. Follow-up is always important to any control method to ensure that it has been eradicated. Surveys of nearby infestations, especially downstream, are also prudent. In Australia, improving pasture conditions in order to allow grass to outcompete *Parkinsonia* is another suggested management technique (DNR 1998).

**Noxious weed acts:** In Australia, *Parkinsonia aculeata* has been declared noxious under the Rural Lands Protection Act 1985 (DNR 1998). Declaration in various counties there put this species in the following two categories: P2, meaning, "the plant must be destroyed. Individual landholders are required to destroy all plants on the land concerned." and P3, meaning, "the number and density of infestations must be



significantly and progressively reduced. Individual landholders are required to destroy all plants or take other action as approved by the local government in accordance with the act.”

#### **MANAGEMENT RECOMMENDATIONS**

The following recommendations for O'ahu are based on current knowledge of its invasive potential, the restricted size of populations, and the potential for dramatic range extension if nothing is done. Sites where *Parkinsonia aculeata* were located in the past should be monitored.

An eye should be kept open for new locations through surveys and monitoring. It would be helpful to find out how widespread *P. aculeata* is on O'ahu and whether eradication would be feasible. *Parkinsonia aculeata* should be added to the state noxious weed list in order to prevent further introduction and spread. The public should be educated to avoid planting potentially invasive plants.

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## Appendix C: Species Profiles (cont.)

*Piper aduncum*

Common name: Spiked pepper

Family: Piperaceae

O‘ahu Early Detection, February 2007

Based on report prepared by: Forest Starr, Kim Starr, and Lloyd Loope of U. S. Geological Survey—  
Biological Resources Division, Haleakala Field Station, Maui, Hawai‘i



Control of *Piper aduncum* infestation in Nahiku, Maui (Photo by [Forest & Kim Starr \(USGS\)](#))

### OVERVIEW

*Piper aduncum* L., native to tropical America, is cultivated in tropical regions of the world and has become invasive in Florida, Fiji, and Papua New Guinea (Gann and Bradley 1999; Rogers and Hartemink 2000). In Papua New Guinea, *P. aduncum* forms large thickets in secondary forests from sea level up to 1,800 m (5,905 ft), similar to *Miconia* infestations in Polynesia (Rogers and Hartemink 2000).

Studies have shown that *P. aduncum* has an invasive advantage over other pioneer species because of its dominance in the seed bank, extremely rapid growth rates, and high rates of biomass accumulation (Rogers and Hartemink 2000). In addition, seeds of *P. aduncum* are rapidly dispersed by mammals and fruit-eating birds, especially by red-vented bulbuls (*Pycnonotus cafer*) in Fiji (Metcalf 1995; PIER 2002; Leps et al. in press). This species was not known to be naturalized in Hawai‘i until recently, when it was reported from Nahiku, Maui. This is the only known naturalized location of *P. aduncum* in the state of Hawai‘i to date;

however, *P. aduncum* is being cultivated (and is spreading locally) at botanical gardens on O‘ahu, and these individuals have been recommended for removal. In Hawai‘i, *P. aduncum* is listed as a state noxious weed (HDOA 1992). We recommend that the public be discouraged from planting or spreading this species.

#### **DESCRIPTION**

“Small tree to 7 m tall, with short silt roots and soft, brittle wood; foliage and twigs aromatic. Branches erect, but with drooping twigs and swollen, purplish nodes. Leaves alternate, distichous, elliptic, 12–22 cm long, shortly petiolate; lamina scabrid above, with sunken nerves, softly hairy beneath. Inflorescence a leaf-opposed, curved spike on a 12–17 cm peduncle, white to pale yellow, turning green with maturity. Flowers crowded in regular transverse ranks. Perianth absent; usually 4 stamens. Fruit a 1-seeded berry, blackish when ripe. Seeds brown to black, 0.7–1.25 mm long, compressed, with a reticulate surface.” (Waterhouse and Mitchell 1998).



Photo by [Forest & Kim Starr \(USGS\)](#)

#### **BIOLOGY & ECOLOGY**

**Pollination:** *Piper aduncum* is possibly wind pollinated (Metcalf 1995). On Maui, *Apis mellifera* (honey bee) were observed on flower spikes.

**Propagation:** *Piper aduncum* is propagated by seed.

**Dispersal:** *Piper aduncum* seeds are dispersed by birds and other animals that are attracted to the succulent fruits (Metcalf 1995). In Fiji, *Pycnonotus cafer* (red-vented bulbul) is the primary dispersal agent of *P. aduncum* (Metcalf 1995). Leps et al. (in press) report that *P. aduncum* germinated in feces of bats in Brazil and of birds, flying foxes, cuscus, and dogs in Papua New Guinea.

**Pests and Diseases:** *Piper* species are susceptible to fungal root rot, pepper weevil, and pepper flea beetle (Brickell & Zuk 1997).

**Invasiveness:** *Piper aduncum* is a common pantropical weed throughout the world. It has readily escaped from cultivation in many places where it is planted to become a dominant part of the landscape. Smith



(1981) reports that, "In Fiji, it is a weed of disturbed rainforest and margins at low elevation, and an aggressive weed from sea level to 400 m (1,312 ft), most often along roadsides and in thickets, but also sometimes in secondary forest or on forested ridges, rarely in intact rain forest."

In Papua New Guinea, where *P. aduncum* has become one of the most successful alien woody plants, the species dominates much of the secondary vegetation up to 1,800 m (5,905 ft) elevation (Rogers & Hartemink 2000). Studies in this area have revealed that *P. aduncum* had a superior seed bank compared to other pioneer species, as well as superior growth rates. They concluded that *P. aduncum* has a competitive advantage over other species and, as a result, poses a serious threat to the indigenous flora (Rogers & Hartemink 2000). In Fiji, *P. aduncum* seeds are dispersed by birds, most notably by red-vented bulbuls (*Pycnonotus cafer*) (PIER 2002; Metcalfe 1995). For these reasons, *P. aduncum* is listed as a state noxious weed in Hawai'i (HDOA 1992).

## **DISTRIBUTION**

**Native range:** *Piper aduncum* is native to tropical rainforests in the West Indies and tropical America (PIER 2002) that have an average annual rainfall ranging from 150–200 cm. (Hammond 1986). According to Rogers and Hartemink (2000), "*P. aduncum* is indigenous to tropical America where it is found from Mexico to Bolivia. Its habitat in Central America is restricted to evergreen vegetation and near watercourses in seasonally deciduous forests, from sea level to about 1,500 m (4,921 ft)."

**Global naturalized distribution:** *Piper aduncum* is cultivated in many tropical regions of the world and is considered a pest in Florida, Fiji, and Papua New Guinea (Rogers & Hartemink 2000; Langeland & Stocker 2002; PIER 2002). In southern Florida, *P. aduncum* forms thickets in woodland margins from sea level to 20 m (66 ft) elevation, mainly invading disturbed dry and rock land hammocks (Gann & Bradley 1999). In these hardwood hammocks, *P. aduncum* tends to invade margins and canopy gaps (Langeland & Stocker 2002). PIER (2002) lists the following areas where *P. aduncum* is present: Fiji, Papua New Guinea, Solomon Islands, Indonesia, Malaysia, Christmas Island, and the United States. In Fiji, Smith (1981) describes the invasion of *P. aduncum* as follows: "In Fiji, an aggressive weed from sea level to 400 m (1,312 ft), most often along roadsides and in thickets, but also sometimes in secondary forest or on forested ridges, rarely in intact rain forests." In Papua New Guinea, *P. aduncum* was first documented from the Morobe Province in 1935 (Rogers & Hartemink 2000). It is currently found in many parts of the humid lowlands at elevations up to 600 m (1,968 ft) and in the highland provinces up to elevations of 1,800 m (5,905 ft) (Rogers & Hartemink 2000). Though not known to invade a closed primary forest in Papua New Guinea, *P. aduncum* does readily invade naturally disturbed areas such as landslides, tree fall gaps, and flooded streambanks (Leps et al. in press).

**State of Hawai'i distribution:** *Piper aduncum* is a state noxious weed in Hawai'i although it was not previously known to be naturalized. It was recently (2002) reported from the island of Maui, where it is locally established in the Nahiku area. The voucher specimen of *P. aduncum* housed at Bishop Museum is from Waimea Arboretum. The status of these populations at this time is uncertain and needs to be investigated further. Other Hawaiian Islands should be monitored for *P. aduncum*.

**Island of O'ahu distribution:** On O'ahu, *P. aduncum* has been collected from Waimea Arboretum. It is also listed in a Lyon Arboretum accession inventory. A recent survey of this garden (Daehler 2006) did not report the species either as naturalized or showing signs of naturalization. Given the invasive nature of this species it is possible that the plant has already been controlled or is being controlled by Arboretum staff.

Based on information from native and invaded ranges elsewhere, it seems likely that *P. aduncum* could, if left unmanaged, eventually occupy large areas of wet disturbed forests on O'ahu throughout the island's elevational range (sea level to 1,225 m).

## **CONTROL METHODS**

**Physical control:** Small seedlings and plants to 2 m (7 ft) can be hand pulled. Larger plants that are not easily hand pulled can be pulled out using a weed wrench or other mechanical means. Residents in the Nahiku area report that *P. aduncum* does not spread vegetatively, nor does it re-root after it is pulled out of



and left on the ground. Plants that are cut and left with their roots in the ground will re-sprout. For this reason, plants that are too large to remove mechanically should be chemically controlled.

**Chemical control:** If hand pulling is not possible or unfeasible, use chemical control methods, including basal bark application of 20% Garlon 4, or cut stump application with 50% Garlon 3A (Langeland & Stocker 2002). In Nahiku, Maui, one resident with *P. aduncum* on his property reports that he has successfully controlled it with the herbicide, Remedy, but has had trouble keeping up with the numerous seedlings that germinate.

**Biological control:** No information on biological controls were found.

**Cultural control:** Do not plant *P. aduncum*. Remove any plants that come up. Wash clothing and gear after use in infested areas.

**Noxious weed status:** *Piper aduncum* is listed on the Hawai'i state noxious weed list (HDOA 1992), making it illegal to possess, propagate, or sell in the state of Hawai'i.

#### MANAGEMENT RECOMMENDATIONS

*Piper aduncum* is a proven aggressive invader in several tropical regions throughout the world. Its invasiveness in Papua New Guinea has been compared to that of *Miconia calvescens* in Polynesia. *P. aduncum* forms thick infestations mostly in disturbed areas along roads and in clearings, but also in naturally disturbed areas such as landslides. It has not yet been found invading deep into the forest. *P. aduncum* was recently reported as naturalized in Nahiku, Maui. It is currently known from one location on O'ahu (Waimea Arboretum) and reported from a second location (Lyon Arboretum). We recommend the known population be controlled as soon as possible and that the reported population be investigated further.

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**Appendix C: Species Profiles (cont.)**

*Topobea parasitica*

Common name: none

Family: Melastomataceae

Tribe: Blakeeae

O'ahu Early Detection, March 2007



**OVERVIEW**

*Topobea parasitica* Aubl., a hemiepiphytic shrub in the family Melastomataceae native to Central and South America, was previously unknown in cultivation. In its native range it is a gap colonizer. Species with this life history trait often exhibit biological characteristics such as high germination rates, rapid growth, and early maturity. They also tend to be efficient at reproduction and dispersal. These traits also increase a plant's likeliness of becoming invasive. In addition to these invasive characteristics, *T. parasitica* is tolerant of shade, meaning it can establish itself in both shaded and open areas. This species is known from only one location on O'ahu and reported from only one other. Given its potential for invasiveness and its relative ease of control, we recommend this species for immediate control.

**DESCRIPTION**

Hemiepiphytic shrub. Young stems inconspicuously quadrangular, young parts pubescent with adpressed bristles about 1 mm in length, also having short trichomes, soon becoming glabrous. Leaf blades broadly elliptic, 6–12 cm in length, 4–8 cm wide, usually with a short, ca 5 mm acuminate apex, bases acute to obtuse, entire, 5-nerved. Petioles 1.5– 4 cm long. Axillary flowers borne below foliage, 1 or more per node.

Pedicels about 12–15 mm. Corolla magenta to pink, petals 1–1.5 cm long, 7–10 mm wide, obovate, recurved at apex. Clawed stamens about 1 cm long, fused into a collar around the style (see photo).



#### **BIOLOGY & ECOLOGY**

**Reproduction:** The pollination of *T. parasitica* is unknown at the species level. One study (Lumer 1999) indicates that species in the genus *Topobea* are pollinated by several species of bees. This study also showed that a closely related species, *T. maurofernandeziana*, was self-compatible—meaning it can reproduce without the presence of another individual. That species is very closely related to *T. parasitica* (D. Penneys, pers. comm.).

**Dispersal:** The small red berries are dispersed by birds.

**Propagation:** This species is extremely rare in cultivation, and propagation information is therefore limited. One source indicates that many species of the tribe Blakeeae can be reproduced by seed and by cuttings.

**Invasiveness:** Due to the extreme rarity of this species in cultivation, its behavior in areas outside of its native range is not known. There are many aspects of its biology and ecology, however, that indicate it could be very invasive. In its native range it is a primary colonizer of naturally disturbed areas and gaps. Species in the Melastomataceae with gap-colonizing characteristics commonly possess life strategies such as high germination rates, rapid growth, early maturity, ability of fragments to root, apomixis, and effective dispersal mechanisms. *Topobea parasitica* exhibits many of these characteristics. Conservative estimates by an expert are that one plant can produce hundreds (but probably thousands) of flowers in a season, and that each fruit contains many dozens (but probably well over a hundred) seeds. It reaches reproductive maturity quickly, within 3 years. Closely related species are shown to be self-compatible. Bird dispersal is very effective in Hawai‘i. Other characteristics contributing to the likelihood of invasiveness include shade tolerance and a vining, epiphytic habit.

#### **DISTRIBUTION**



**Native range:** *Topobea parasitica* is one of the most widespread species in the genus. Its native range is from Costa Rica to Colombia to French Guiana, mostly below 1000 m.

**Non-native distribution:** This species is extremely rare in cultivation, and is not documented from anywhere outside its native range. Reports indicate it may be very rarely cultivated in California as well as on O'ahu.

**State of Hawai'i distribution:** This species is not known from any island other than O'ahu.

**Island of O'ahu distribution:** *Topobea parasitica* is known from only one confirmed location on O'ahu, at Foster Botanical Garden. At the time of the survey the plant was being grown in a pot, and was flowering. A garden employee is monitoring this plant for fruit production and has not reported any as of yet. The plant is also reported to be growing at a residence of another garden employee.

#### **CONTROL METHODS**

**Physical and Chemical control:** No control has been performed on this species previously. Potted plants can simply be contained and removed. For larger plants growing in the ground, chemical control may be necessary. Cut-stump treatments with Garlon 4 (active ingredient triclopyr) would likely be effective. Since no chemical treatments have been tested, plants treated this way should be monitored closely for effectiveness.

**Cultural control:** Any further cultivation and distribution of this plant should be strongly discouraged.

**Noxious weed acts:** This plant is not currently listed as a noxious weed, but has likely never been considered as one. This species, and any related species exhibiting similar biological characteristics, should be considered for inclusion in the Hawai'i State Noxious weed list, and possibly the USDA Federal Noxious weed list.

#### **MANAGEMENT RECOMMENDATIONS**

Due to the likelihood of this plant becoming invasive, its very limited population size, and probable lack of dispersal outside of cultivation, it is recommended this species be controlled as soon as possible. Because this plant is not a listed noxious weed, cooperation from landowners must be attained.

#### **REFERENCES**

- Lumer, C. 1999. The reproductive biology of *Blakea* and *Topobea* (Melastomataceae). In: Nadkarni & Wheelwright, eds. Monteverde: Ecology and conservation of a Tropical Cloud Forest. Oxford Univ. Press, USA.)
- Penneys, D. 2007. Melastomataceae of the World. Accessed 7 March, 2007 from [http://www.flmnh.ufl.edu/melastomes/melastome\\_blakeae\\_table.htm](http://www.flmnh.ufl.edu/melastomes/melastome_blakeae_table.htm).
- Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1999. *Manual of the Flowering Plants of Hawai'i*. 2 vols. Bishop Museum Special Publication 83, University of Hawai'i and Bishop Museum Press, Honolulu, HI.

### Appendix D: Specimen ID Inventory

The following is a running list of specimens or photos deposited with the O'ahu Early Detection team between July 2006 and April 2007 by field staff of various agencies (e.g., OISC, U.S. Army Environmental) and OED itself. The list is adapted from a database OED maintains to track the status of each specimen it evaluates.

ID	1	Species	cassine
Accession #		New record?	
Sheet #		Donor	Army
Family	Melastomataceae	Collector	K. Kawelo
Genus	Medinilla	Collector #	
Species	magnifica	Island	O
New record?	Island (nat)	Where collected	Schofield
Donor	OISC	Coll date	7.2006
Collector	J. P. Fisher	Photo date	
Collector #		Add to list?	evaluate
Island	O	Date determined	
Where collected	Nu'uuanu, near Judd trail	Sent to (Institution)	
Coll date	6.30.2006	Date sent	
Photo date		Determiner	
Add to list?	yes	Notes	
Date determined		ID	4
Sent to (Institution)		Accession #	
Date sent		Sheet #	
Determiner		Family	Flacourtiaceae
Notes		Genus	Flacourtia
ID	2	Species	jangomas
Accession #	2007.022	New record?	
Sheet #		Donor	OISC
Family	Pittosporaceae	Collector	J. Spencer
Genus	Pittosporum	Collector #	
Species	pentandrum	Island	O
New record?		Where collected	Maunawili
Donor	OED	Coll date	7.2006
Collector	OED	Photo date	
Collector #		Add to list?	evaluate
Island	O	Date determined	
Where collected	Halawa, near H-3 on ramp from Ulune St	Sent to (Institution)	
Coll date	7.12.2006	Date sent	
Photo date		Determiner	
Add to list?	already on list	Notes	
Date determined		ID	5
Sent to (Institution)		Accession #	
Date sent		Sheet #	
Determiner		Family	Melastomataceae
Notes		Genus	Oxyspora?
ID	3	Species	paniculata?
Accession #		New record?	
Sheet #		Donor	
Family	Aquifoliaceae	Collector	Noel
Genus	Ilex	Collector #	
		Island	O
		Where collected	Maunawili

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Coll date	7.2006	Determiner	
Photo date		Notes	
Add to list?	evaluate		
Date determined		ID	8
Sent to (Institution)		Accession #	
Date sent		Sheet #	
Determiner		Family	Fabaceae
Notes	could be first record of <i>Oxyspora</i> on windward side. Found in Maunawili about a quarter mile from hairpin turn on Ko'olau Poko trail, below trail. More than one plant, area was flagged.	Genus	Ceratonia
		Species	siliqua
		New record?	
		Donor	OED
		Collector	OED
		Collector #	
		Island	O
		Where collected	Keolu
ID	6	Coll date	8.10.2006
Accession #	2007.022	Photo date	8.10.06
Sheet #		Add to list?	evaluate
Family	Melastomataceae	Date determined	
Genus	Topobea	Sent to (Institution)	
Species	parasitica	Date sent	
New record?	State (cult)	Determiner	
Donor	OED	Notes	
Collector	OED		
Collector #		ID	9
Island	O	Accession #	
Where collected	Foster Botanical Garden	Sheet #	
Coll date	7.21.2006	Family	Sapindaceae
Photo date		Genus	Cardiospermum
Add to list?	evaluate	Species	?
Date determined		New record?	
Sent to (Institution)		Donor	OED
Date sent		Collector	OED
Determiner		Collector #	
Notes	Identified by Darin Penneys (Univ. Florida) through detailed photos	Island	O
		Where collected	Waimanalo, Kakaina Pl.
		Coll date	8.10.2006
		Photo date	8.10.06
		Add to list?	
		Date determined	
		Sent to (Institution)	
		Date sent	
		Determiner	
		Notes	determine, need flowers
ID	7	ID	10
Accession #		Accession #	
Sheet #		Sheet #	
Family	Piperaceae	Family	Acanthaceae
Genus	Piper	Genus	Justicia
Species	lolot	Species	spicigera
New record?		New record?	
Donor	OED	Donor	OED
Collector	OED	Collector	OED
Collector #		Collector #	
Island	O	Island	O
Where collected	Nu'uaniu Pali Dr.		
Coll date	8.10.2006		
Photo date	8.10.06		
Add to list?	evaluate		
Date determined			
Sent to (Institution)			
Date sent			

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Where collected	Nu'uaniu Pali Dr.	Genus	Medinilla
Coll date	8.10.2006	Species	magnifica
Photo date		New record?	
Add to list?	no	Donor	OISC
Date determined		Collector	K. Metzler
Sent to (Institution)		Collector #	A10
Date sent		Island	O
Determiner		Where collected	Ahuimanu right
Notes		Coll date	
		Photo date	
ID	11	Add to list?	evaluate
Accession #	2006.144	Date determined	
Sheet #	721767	Sent to (Institution)	
Family	Acanthaceae	Date sent	
Genus	Odontonema	Determiner	
Species	cuspidatum	Notes	not included in collection because specimen was not fertile
New record?	Island (nat)		
Donor	OED	ID	14
Collector	OED	Accession #	
Collector #	608102	Sheet #	
Island	O	Family	Acanthaceae
Where collected	Nu'uaniu Pali Dr.	Genus	Hemigraphis
Coll date	8.10.2006	Species	reptans
Photo date		New record?	
Add to list?	no	Donor	OISC
Date determined		Collector	K. Metzler
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Ahuimanu right
Notes		Coll date	
		Photo date	
ID	12	Add to list?	no
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Acanthaceae	Date sent	
Genus	Dicliptera	Determiner	
Species	chinensis	Notes	
New record?			
Donor	OED	ID	15
Collector	OED	Accession #	
Collector #	608103	Sheet #	
Island	O	Family	Poaceae
Where collected	Nu'uaniu Pali Dr.	Genus	Cortaderia
Coll date	8.10.2006	Species	jubata?
Photo date		New record?	
Add to list?	no	Donor	OISC
Date determined		Collector	OISC
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	'Aiea Heights
Notes		Coll date	
		Photo date	
ID	13	Add to list?	yes
Accession #		Date determined	
Sheet #			
Family	Melastomataceae		



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Sent to (Institution)		Species	humilis
Date sent		New record?	
Determiner		Donor	OED
Notes	collected at Keaiwa Heiau, plant was ripped up and herbicided, will need a future visit to finish control	Collector	photo
		Collector #	
		Island	O
		Where collected	McCully
		Coll date	photo
ID	16	Photo date	
Accession #		Add to list?	no
Sheet #		Date determined	
Family	Fabaceae	Sent to (Institution)	
Genus	Lotus	Date sent	
Species	uliginosus	Determiner	
New record?		Notes	Punahou+King
Donor	OED		
Collector	OED	ID	19
Collector #		Accession #	
Island	H	Sheet #	
Where collected	Hakalau	Family	Asclepiadaceae
Coll date		Genus	Telosma
Photo date	8.20.06	Species	cordata
Add to list?	evaluate	New record?	
Date determined		Donor	OED
Sent to (Institution)		Collector	photo
Date sent		Collector #	
Determiner		Island	O
Notes		Where collected	McCully
		Coll date	photo
ID	17	Photo date	
Accession #		Add to list?	no
Sheet #		Date determined	
Family	Bignoniaceae	Sent to (Institution)	
Genus	Tabebuia?	Date sent	
Species	chrysotricha?	Determiner	
New record?		Notes	Punahou+King
Donor	OED		
Collector	photo	ID	20
Collector #		Accession #	
Island	O	Sheet #	
Where collected	Keolu	Family	Verbenaceae
Coll date	photo	Genus	Clerodendrum
Photo date	8.10.06	Species	indicum
Add to list?	evaluate	New record?	
Date determined		Donor	OED
Sent to (Institution)		Collector	photo
Date sent		Collector #	
Determiner		Island	O
Notes	photo'd in Keolu, <i>T.</i> <i>chrysotricha</i> exists at Foster	Where collected	Kalihi
		Coll date	photo
ID	18	Photo date	
Accession #		Add to list?	evaluate
Sheet #		Date determined	
Family	Phytolaccaceae	Sent to (Institution)	
Genus	Rivina	Date sent	
		Determiner	

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Notes	In weed lot of Bishop Museum grounds	Collector #	
		Island	M
		Where collected	
ID	21	Coll date	
Accession #	2007.022	Photo date	
Sheet #		Add to list?	evaluate
Family	Rosaceae	Date determined	
Genus	Eriobotrya	Sent to (Institution)	
Species	japonica	Date sent	
New record?	Island (nat)	Determiner	
Donor	OED	Notes	looks pretty close, need confirmation from an expert
Collector	A. Lau		
Collector #			
Island	O	ID	24
Where collected	Kalihi	Accession #	
Coll date	8.12.2006	Sheet #	
Photo date		Family	Malvaceae
Add to list?	already on list	Genus	Hibiscus
Date determined		Species	acetosella
Sent to (Institution)		New record?	
Date sent		Donor	H. Oppenheimer
Determiner		Collector	H. Oppenheimer
Notes		Collector #	H110506
		Island	M
ID	22	Where collected	Lahaina, Kahana, Maui
Accession #		Coll date	11.14.2005
Sheet #		Photo date	
Family	Passifloraceae	Add to list?	no
Genus	Passiflora	Date determined	
Species	indet	Sent to (Institution)	
New record?		Date sent	
Donor	Forest & Kim Starr	Determiner	
Collector	Forest & Kim Starr	Notes	showing signs of naturalization
Collector #			
Island	M		
Where collected	Floral Enchanting Gardens, Kula	ID	25
		Accession #	
Coll date		Sheet #	
Photo date		Family	Malvaceae
Add to list?	evaluate	Genus	Sida
Date determined		Species	urens
Sent to (Institution)		New record?	Range extension
Date sent		Donor	H. Oppenheimer
Determiner		Collector	H. Oppenheimer
Notes	need to send to MO, John McDougal	Collector #	H100521
		Island	M
		Where collected	W. Maui, Lahaina, 1920 ft
ID	23	Coll date	10.27.2005
Accession #		Photo date	
Sheet #		Add to list?	evaluate
Family	Ericaceae	Date determined	
Genus	Erica	Sent to (Institution)	
Species	lusitanica?	Date sent	
New record?		Determiner	
Donor	Forest & Kim Starr	Notes	
Collector	Forest & Kim Starr		

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ID	26	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Melastomataceae	Date sent	
Genus	Tibouchina	Determiner	
Species	herbacea	Notes	
New record?	Island (nat)		
Donor	H. Oppenheimer	ID	29
Collector	H. Oppenheimer	Accession #	2006.144
Collector #	H8054	Sheet #	721764
Island	Mo	Family	Vitaceae
Where collected	Moloka'i	Genus	Cissus
Coll date	8.12.2005	Species	sp.
Photo date		New record?	
Add to list?	already on list	Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	608101
Date sent		Island	O
Determiner		Where collected	Waimanalo, Kakaina Pl.
Notes	found in taro loi	Coll date	8.10.2006
		Photo date	
ID	27	Add to list?	evaluate
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Fabaceae	Date sent	
Genus	Canavalia	Determiner	
Species	molokaiensis	Notes	Along side of road, growing over Leucaena
New record?			
Donor	H. Oppenheimer	ID	30
Collector	H. Oppenheimer	Accession #	2006.144
Collector #		Sheet #	721765
Island	Mo	Family	Menispermaceae
Where collected	Moloka'i	Genus	Cocculus?
Coll date		Species	sp.
Photo date		New record?	
Add to list?	no	Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	608081
Date sent		Island	O
Determiner		Where collected	Ala Wai Community Garden, Honolulu
Notes		Coll date	8.8.2006
ID	28	Photo date	
Accession #		Add to list?	evaluate
Sheet #		Date determined	
Family	Araceae	Sent to (Institution)	
Genus	Epipremnum	Date sent	
Species	pinnatum	Determiner	
New record?		Notes	
Donor	H. Oppenheimer	ID	31
Collector	H. Oppenheimer	Accession #	2006.144
Collector #		Sheet #	721769
Island		Family	Boraginaceae
Where collected		Genus	Carmona
Coll date			
Photo date			

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Species	retusa	Notes	
New record?			
Donor	OED	ID	34
Collector	OED	Accession #	
Collector #	608104	Sheet #	
Island	O	Family	Fabaceae
Where collected	Waimanalo, Kakaina Pl.	Genus	Leucaena
Coll date	8.10.2006	Species	Xspontanea
Photo date		New record?	
Add to list?	evaluate	Donor	H. Oppenheimer
Date determined		Collector	H. Oppenheimer
Sent to (Institution)		Collector #	30511
Date sent		Island	M
Determiner		Where collected	
Notes		Coll date	7.2005
		Photo date	
ID	32	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Sapotaceae	Date sent	
Genus	Mimusops?	Determiner	
Species	caffra?	Notes	
New record?			
Donor	G. Staples	ID	35
Collector	G. Staples	Accession #	
Collector #		Sheet #	
Island	O	Family	Asteraceae
Where collected	Honolulu, Vineyard Zippy's	Genus	Calyptocarpus
Coll date		Species	vialis
Photo date		New record?	
Add to list?	evaluate	Donor	H. Oppenheimer
Date determined		Collector	H. Oppenheimer
Sent to (Institution)		Collector #	40508
Date sent		Island	M
Determiner		Where collected	
Notes		Coll date	7.2005
		Photo date	
ID	33	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Campanulaceae	Date sent	
Genus	Cyanea	Determiner	
Species	maritae	Notes	
New record?			
Donor	H. Oppenheimer	ID	36
Collector	H. Oppenheimer	Accession #	
Collector #	120403	Sheet #	
Island	M	Family	Santalaceae
Where collected		Genus	Santalum
Coll date	7.2005	Species	album
Photo date		New record?	
Add to list?		Donor	H. Oppenheimer
Date determined		Collector	H. Oppenheimer
Sent to (Institution)		Collector #	50503
Date sent		Island	M
Determiner		Where collected	



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Coll date	7.2005	Species	elegans subsp. formosana
Photo date		New record?	
Add to list?		Donor	Forest & Kim Starr
Date determined		Collector	Forest & Kim Starr
Sent to (Institution)		Collector #	
Date sent		Island	M
Determiner		Where collected	Ulupalakua?
Notes		Coll date	
ID	37	Photo date	
Accession #	2007.022	Add to list?	no
Sheet #		Date determined	02.07.2007
Family	Aquifoliaceae	Sent to (Institution)	
Genus	Ilex	Date sent	
Species	dimorphophylla?	Determiner	
New record?	State (cult)	Notes	
Donor	OED	ID	40
Collector	OED	Accession #	
Collector #		Sheet #	
Island	O	Family	Solanaceae
Where collected	Home Depot Iwilei	Genus	Solanum
Coll date	9.07.06	Species	rostratum
Photo date	9.07.06	New record?	
Add to list?	evaluate	Donor	Forest & Kim Starr
Date determined		Collector	Forest & Kim Starr
Sent to (Institution)		Collector #	
Date sent		Island	M
Determiner		Where collected	Ulupalakua?
Notes		Coll date	
ID	38	Photo date	
Accession #		Add to list?	
Sheet #		Date determined	02.07.2007
Family	Rubiaceae	Sent to (Institution)	
Genus	Gardenia	Date sent	
Species	cf. taitensis	Determiner	
New record?		Notes	
Donor	Wayne Gau	ID	41
Collector		Accession #	
Collector #		Sheet #	
Island	O	Family	Elaeocarpaceae
Where collected		Genus	Elaeocarpus
Coll date	2.2.2007	Species	cf. angustifolia
Photo date		New record?	
Add to list?	no	Donor	Army
Date determined		Collector	Army
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Kahuku Training Area
Notes		Coll date	10.5.06
ID	39	Photo date	
Accession #		Add to list?	no
Sheet #		Date determined	
Family	Sapindaceae	Sent to (Institution)	
Genus	Koelreuteria	Date sent	
		Determiner	

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Notes		Where collected	
ID	42	Coll date	12.06
Accession #		Photo date	
Sheet #		Add to list?	
Family	Burseraceae	Date determined	
Genus	Bursera	Sent to (Institution)	
Species	hindsiana	Date sent	
New record?		Determiner	
Donor	OISC	Notes	
Collector	OISC	ID	45
Collector #	A13	Accession #	
Island	O	Sheet #	
Where collected	Ahuimanu St.	Family	Cyperaceae
Coll date	12.06	Genus	Cyperus
Photo date		Species	polystachyos
Add to list?	no	New record?	
Date determined		Donor	
Sent to (Institution)		Collector	R. Smith
Date sent		Collector #	
Determiner		Island	O
Notes		Where collected	
ID	43	Coll date	12.06
Accession #		Photo date	
Sheet #		Add to list?	
Family	Polygonaceae	Date determined	
Genus	?	Sent to (Institution)	
Species	?	Date sent	
New record?		Determiner	
Donor	OISC	Notes	
Collector	OISC	ID	46
Collector #	A14	Accession #	
Island		Sheet #	
Where collected		Family	Poaceae
Coll date		Genus	Isachne
Photo date		Species	distichophylla
Add to list?		New record?	
Date determined		Donor	
Sent to (Institution)		Collector	R. Smith
Date sent		Collector #	
Determiner		Island	O
Notes	need flowers for ID, recollect?	Where collected	Halawa
ID	44	Coll date	12.06
Accession #		Photo date	
Sheet #		Add to list?	
Family	Oleaceae	Date determined	
Genus	Fraxinus	Sent to (Institution)	
Species	uhdei	Date sent	
New record?		Determiner	
Donor		Notes	
Collector	R. Smith	ID	47
Collector #		Accession #	
Island	O	Sheet #	
		Family	Areaceae

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Genus	Pinanga	Determiner	
Species	coronata	Notes	
New record?			
Donor		ID	50
Collector	R. Smith	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Fabaceae
Where collected		Genus	Acacia
Coll date	12.06	Species	auriculiformis
Photo date		New record?	State (nat)
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	611291
Date sent		Island	O
Determiner		Where collected	Waimanalo Ag Exp. Sta.
Notes		Coll date	11.29.06
		Photo date	11.29.06
ID	48	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Myrtaceae	Date sent	
Genus	Syncarpia	Determiner	
Species	glomulifera	Notes	
New record?			
Donor		ID	51
Collector	R. Smith	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Fabaceae
Where collected		Genus	Acacia
Coll date	12.06	Species	auriculiformis
Photo date		New record?	State (nat)
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	611292
Date sent		Island	O
Determiner		Where collected	Waimanalo Ag Exp. Sta.
Notes		Coll date	11.29.06
		Photo date	11.29.06
ID	49	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Oleaceae	Date sent	
Genus	Noronhia	Determiner	
Species	emarginata	Notes	Thought was <i>A. mangium</i> , but D. Siegler said both were <i>auriculiformis</i>
New record?			
Donor		ID	52
Collector	R. Smith	Accession #	
Collector #		Sheet #	
Island	O	Family	Solanaceae
Where collected		Genus	Solanum
Coll date	12.06	Species	mauritianum
Photo date		New record?	
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)			
Date sent			

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Collector #		Accession #	2007.022
Island	O	Sheet #	
Where collected	Whitmore Village	Family	Clusiaceae
Coll date	2.26.07	Genus	Tripetalum
Photo date		Species	cymosum
Add to list?		New record?	
Date determined		Donor	OED
Sent to (Institution)		Collector	OED
Date sent		Collector #	
Determiner		Island	O
Notes		Where collected	Waimea BG
		Coll date	1.25.07
ID	53	Photo date	
Accession #		Add to list?	
Sheet #		Date determined	
Family	Celastraceae	Sent to (Institution)	
Genus	Catha	Date sent	
Species	edulis	Determiner	
New record?	poss. State (nat)	Notes	
Donor	OED		
Collector	OED	ID	56
Collector #		Accession #	2007.022
Island	O	Sheet #	
Where collected	Drum Road	Family	Urticaceae
Coll date	2.26.07	Genus	Procris
Photo date		Species	pedunculata
Add to list?		New record?	State (nat)
Date determined		Donor	OED
Sent to (Institution)		Collector	OED
Date sent		Collector #	
Determiner		Island	O
Notes	In inventory of Waimea BG-spreading? Ask K. Kawelo	Where collected	Waimea BG
		Coll date	1.25.07
ID	54	Photo date	
Accession #	2007.022	Add to list?	
Sheet #	725935	Date determined	
Family	Bignoniaceae	Sent to (Institution)	
Genus	Radermachera	Date sent	
Species	sinica	Determiner	
New record?		Notes	
Donor	OED		
Collector	OED	ID	57
Collector #		Accession #	2007.022
Island	O	Sheet #	
Where collected	Waimea BG	Family	Fabaceae
Coll date	1.25.07	Genus	Vigna
Photo date		Species	hosei
Add to list?		New record?	
Date determined		Donor	OED
Sent to (Institution)		Collector	OED
Date sent		Collector #	
Determiner		Island	O
Notes		Where collected	Waimea BG
		Coll date	1.25.07
ID	55	Photo date	
		Add to list?	



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Date determined		Collector	OED
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Waimea BG
Notes		Coll date	1.25.07
		Photo date	
ID	58	Add to list?	
Accession #	2007.023	Date determined	
725064		Sent to (Institution)	
Family	Vitaceae	Date sent	
Genus	Vitex	Determiner	
Species	trifolium	Notes	
New record?	State (nat)		
Donor	Army	ID	61
Collector	K. Kawelo	Accession #	2007.022
Collector #	USArmy38	Sheet #	
Island	O	Family	Sapindaceae
Where collected	SBE	Genus	Allophylus
Coll date	2.5.07	Species	cobbe
Photo date		New record?	State (nat)
Add to list?		Donor	OED
Date determined	2.5.07	Collector	OED
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Waimea BG
Notes		Coll date	1.25.07
		Photo date	
ID	59	Add to list?	
Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Malvaceae	Date sent	
Genus	Hibiscus	Determiner	
Species	makinoi	Notes	
New record?	State (nat)		
Donor	OED	ID	62
Collector	OED	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Fabaceae
Where collected	Waimea BG	Genus	Vigna
Coll date	1.25.07	Species	speciosa
Photo date		New record?	
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Waimea BG
Notes		Coll date	1.25.07
		Photo date	
ID	60	Add to list?	
Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Nyctaginaceae	Date sent	
Genus	Pisonia	Determiner	
Species	alba	Notes	
New record?			
Donor	OED	ID	63

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Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Piperaceae	Date sent	
Genus	Piper	Determiner	
Species	aduncum	Notes	
New record?			
Donor	OED	ID	66
Collector	OED	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Araliaceae
Where collected	Waimea BG	Genus	Schefflera
Coll date	1.25.07	Species	insularum
Photo date		New record?	
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Ho'omaluhia BG
Notes		Coll date	2.1.07
		Photo date	
ID	64	Add to list?	
Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Costaceae	Date sent	
Genus	Costus	Determiner	
Species	speciosus	Notes	
New record?	Island (nat)		
Donor	OED	ID	67
Collector	OED	Accession #	2007.023
Collector #		Sheet #	725065
Island	O	Family	Podocarpaceae
Where collected	Waimea BG	Genus	Podocarpus
Coll date	1.25.07	Species	chinensis
Photo date		New record?	State (nat)
Add to list?		Donor	Army
Date determined		Collector	K. Kawelo
Sent to (Institution)		Collector #	USArmy37
Date sent		Island	O
Determiner		Where collected	'Ahuimanu Valley
Notes		Coll date	1.27.07
		Photo date	
ID	65	Add to list?	
Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Bromeliaceae	Date sent	
Genus	Aechmea	Determiner	
Species	bracteata	Notes	
New record?	State (nat)		
Donor	OED	ID	68
Collector	OED	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Fabaceae
Where collected	Waimea BG	Genus	Acacia
Coll date	1.25.07	Species	mangium
Photo date		New record?	State (nat)
Add to list?		Donor	OED

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Collector	OED	ID	72
Collector #		Accession #	2007.022
Island	O	Sheet #	725947
Where collected	Ho'omaluhia BG	Family	Turneraceae
Coll date	2.1.07	Genus	Turnera
Photo date		Species	ulmifolia
Add to list?		New record?	Island (nat)
Date determined		Donor	OED
Sent to (Institution)		Collector	OED
Date sent		Collector #	
Determiner		Island	O
Notes		Where collected	Near Bishop
		Coll date	11.7.06
ID	69	Photo date	
Accession #	2007.022	Add to list?	
Sheet #		Date determined	
Family	Convolvulaceae	Sent to (Institution)	
Genus	Poranopsis	Date sent	
Species	paniculata	Determiner	
New record?		Notes	Found growing in wall
Donor	OED	ID	73
Collector	OED	Accession #	2007.023
Collector #		Sheet #	725063
Island	O	Family	Fabaceae
Where collected	He'eia State Park	Genus	Crotalaria
Coll date	1.27.07	Species	sp.
Photo date		New record?	
Add to list?		Donor	Army
Date determined		Collector	Jan Nakamura
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	SBE
Notes		Coll date	11.14.06
		Photo date	
ID	71	Add to list?	
Accession #	2007.025	Date determined	
Sheet #	725062	Sent to (Institution)	
Family	Anacardiaceae	Date sent	
Genus	Rhus	Determiner	
Species	taitensis	Notes	
New record?		ID	74
Donor	Honolulu Botanical Garden	Accession #	2007.022
Collector	N. Hoffmann	Sheet #	
Collector #		Family	Vitaceae
Island	O	Genus	Tetrastigma
Where collected	Ho'omaluhia BG	Species	voinieranum
Coll date	12.11.06	New record?	poss. State (nat)
Photo date		Donor	OED
Add to list?		Collector	OED
Date determined		Collector #	
Sent to (Institution)		Island	O
Date sent		Where collected	Waimea BG
Determiner		Coll date	12.7.06
Notes	Daehler, Baker found nat. in Lyon	Photo date	

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Add to list?		Genus	Tillandsia
Date determined		Species	usneoides
Sent to (Institution)		New record?	State (nat)
Date sent		Donor	OED
Determiner		Collector	OED
Notes	Poss. spreading vegetatively- Waimea was removing it	Collector #	
		Island	O
		Where collected	Waimea
ID	75	Coll date	12.7.06
Accession #		Photo date	
Sheet #		Add to list?	
Family	Onagraceae	Date determined	
Genus	Ludwigia	Sent to (Institution)	
Species	sp.	Date sent	
New record?		Determiner	
Donor	OED	Notes	
Collector	OED		
Collector #		ID	78
Island	O	Accession #	2007.022
Where collected	Waimea BG	Sheet #	
Coll date	12.7.06	Family	Menispermaceae
Photo date		Genus	Stephania
Add to list?		Species	japonica
Date determined		New record?	
Sent to (Institution)		Donor	OED
Date sent		Collector	OED
Determiner		Collector #	
Notes	Spreading in pond- no flowers. Will need flowers for ID.	Island	O
		Where collected	Waimea
		Coll date	12.7.06
		Photo date	
ID	76	Add to list?	
Accession #		Date determined	
Sheet #		Sent to (Institution)	
Family	Clusiaceae	Date sent	
Genus	Clusia	Determiner	
Species	sp.	Notes	Pigs spreading it up hill
New record?			
Donor	OED	ID	79
Collector	OED	Accession #	2007.022
Collector #		Sheet #	
Island	O	Family	Verbenaceae
Where collected	Waimea BG	Genus	Clerodendrum
Coll date	12.7.06	Species	buchanani
Photo date		New record?	Island (nat)
Add to list?		Donor	OED
Date determined		Collector	OED
Sent to (Institution)		Collector #	
Date sent		Island	O
Determiner		Where collected	Waimea
Notes	Need to send off for ID	Coll date	12.7.06
		Photo date	
ID	77	Add to list?	
Accession #	2007.022	Date determined	
Sheet #		Sent to (Institution)	
Family	Bromeliaceae	Date sent	



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Determiner		Where collected	Wahiawa
Notes		Coll date	
ID	80	Photo date	
Accession #		Add to list?	
Sheet #		Date determined	
Family	Rubiaceae	Sent to (Institution)	
Genus	Gardenia	Date sent	
Species	augusta	Determiner	
New record?		Notes	
Donor	A. Lau	ID	84
Collector	A. Lau	Accession #	
Collector #		Sheet #	
Island	O	Family	Poaceae
Where collected	Kalihi	Genus	Avena
Coll date	8.12.06	Species	fatua
Photo date		New record?	
Add to list?		Donor	Army
Date determined		Collector	K. Kawelo
Sent to (Institution)		Collector #	US Army 45
Date sent		Island	O
Determiner		Where collected	Bottom of NIKE site Rd.
Notes		Coll date	4.10.07
ID	81	Photo date	
Accession #	2006.131	Add to list?	n
Sheet #		Date determined	4.17.07
Family	Poaceae	Sent to (Institution)	
Genus	cf. Schizachyrium	Date sent	
Species	condensatum	Determiner	
New record?		Notes	
Donor	OISC	ID	85
Collector	OISC	Accession #	
Collector #	OISCA004	Sheet #	
Island	O	Family	Poaceae
Where collected	'Ahuimanu Cliffs	Genus	Pennisetum
Coll date	5.25.06	Species	purpureum
Photo date		New record?	
Add to list?		Donor	Army
Date determined		Collector	K. Kawelo
Sent to (Institution)		Collector #	US Army 46
Date sent		Island	O
Determiner		Where collected	Bottom of NIKE site Rd., Mokule'ia
Notes		Coll date	4.10.07
ID	82	Photo date	
Accession #		Add to list?	n
Sheet #		Date determined	4.17.07
Family	Melastomataceae	Sent to (Institution)	
Genus	Tibouchina	Date sent	
Species	heteromalla	Determiner	
New record?	State (cult)	Notes	
Donor	OISC	ID	86
Collector	OISC	Accession #	
Collector #		Sheet #	
Island	O		

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Family	Fabaceae
Genus	Macrotidium
Species	lathyroides
New record?	
Donor	Dr. S. Keeley
Collector	
Collector #	
Island	L
Where collected	
Coll date	
Photo date	4.11.07
Add to list?	
Date determined	4.12.07
Sent to (Institution)	
Date sent	
Determiner	
Notes	Photo sent to us for ID